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The Potential for Improving Acifluorfen Efficacy by Rate Refinement and Sequential Applications (Morningglory, Cocklebur, Soybean).

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THE POTENTIAL FOR IMPROVING ACIFLUORFEN EFFICACY BY RATE REFINEMENT AND SEQUENTIAL APPLICATIONS

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
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in

The Department of Plant Pathology and Crop Physiology

by

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B.S., Mississippi State University, 1978
M.S., Mississippi State University, 1979
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Finally, the author wishes to dedicate this dissertation to his parents, Mr. and Mrs. Doyle Crowder, and his future wife, Carol Ann Goldbach, whose love and support made this manuscript possible.

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ABSTRACT

Field and greenhouse studies were conducted in 1981 and 1982 to evaluate acifluorfen [5-[2-chloro-4-trifluoromethyl)phenoxy]2=nitrobenozic acid] efficacy in controlling morningglory (Ipomea spp.) and common cocklebur (Xanthium pennsylvanicum Wallr.) in soybeans [Glycine max (L.) Merr.]. Repeated low rate applications of 0.2 kg/ha active ingredient acifluorfen were compared to single applications for control of ivyleaf morningglory [Ipomea hederacea (L.) Jacq. var: hederacea]. In field studies two applications of 0.2 kg/ha acifluorfen increased control compared to a single application of 0.6 kg/ha, based on visual ratings and fresh weight reductions in ivyleaf morningglory.

In the response of ivyleaf morningglory to increasing rates of acifluorfen, maximum control under greenhouse conditions was achieved at rates of 0.6 to 0.9 kg/ha. Deviation from 100% control at higher rates was due to regrowth at the axillary buds of the lower nodes of treated plants. In one field study, conducted under dry conditions, the rate of increase in percent control as acifluorfen rates increased from 0.3 to 1.2 kg/ha was low compared to results from an experiment conducted under favorable conditions. Since fresh weight measurements often reflected regrowth at the nodes of treated plants, studies on the effect of acifluorfen rate of application on translocation to the leaf node and lower stem was quantified. Differences in ^{14}C-acifluorfen translocation to the lower stem was observed between 24, 48, and 72 hour analysis periods. Rates ranging from 0.15 to 1.2 kg/ha of ^{14}C-acifluorfen were applied to ivyleaf morningglory leaves in a similar study. The amount of ^{14}C-acifluorfen equivalent translocated increased linearly with

increasing field rates. Larger amounts of ^{14}C-acifluorfen accumulated in the nodes of the treated leaves compared to the lower stem area.

In other field studies the potential of mefluidide [N-[2,4-dimethyl-5-[[(trifluoromethyl-sulfonyl]amino]phenyl]acetamide] applied in combination with acifluorfen to increase control of pitted morningglory [*Ipomea lacunosa* (L.)] and common cocklebur was examined. All treatments with mefluidide in combination with acifluorfen improved both pitted morningglory and cocklebur control compared to acifluorfen applied alone. The sequential applications of acifluorfen following mefluidide increased control of both weeds compared to the tank-mix combinations.

INTRODUCTION

Two of the most troublesome weeds found in Southern soybean [Glycine max (L.) Merr.] fields are common cocklebur [Xanthium pennsylvanicum (L.) Wallr.] and morningglory (Ipomea spp.). Effective, yet expensive, postemergence herbicides are presently available for control of specific weed pests. With the cost of herbicides increasing, development of morningglory and cocklebur control programs utilizing less herbicide and maintaining effective control would be of great economic value to the soybean producer.

Cocklebur often causes soybean yield reductions of 50 - 80% (10). In evaluation of postemergence herbicides, Overton et al. (37) emphasized the need for early control of cocklebur in soybeans. Often repeated applications of overtop herbicides along with cultivation are needed to establish effective control (34, 37).

Ivyleaf morningglory [Ipomea hederacea (L.) Jacq. var: hederacea] and pitted morningglory [Ipomea lacunosa (L.)] have been reported as having the highest biomass compared to other morningglory species grown under the same conditions (5). Foliage growth in later stages causes difficulty in achieving complete coverage with herbicide sprays. Season-long competition with soybeans may reduce yield as much as 70% (36, 51).

Several overtop herbicides are presently available for control of morningglory and cocklebur. In the 1970's, Rohm and Haas Company developed a new diphenyl ether herbicide, acifluorfen (5-[2-chloro-4-trifluoromethyl)phenoxy]-2-nitrobenzoic acid), registered for broadleaf weed control in soybeans (7, 14). Many factors affect the performance of acifluorfen as an overtop broadleaf herbicide, such as herbicide timing, weed stage of development at application, herbicide combinations, environmental conditions and acifluorfen application rate. Preliminary field studies indicated less herbicide efficacy from a higher rate of acifluorfen compared to slightly lower rates.[1/]

The objectives of this research were (a) to study the effect of acifluorfen rate on herbicide efficacy in field and greenhouse studies, (b) to study the effect of acifluorfen rate on translocation of ^{14}C-acifluorfen, and (c) to evaluate acifluorfen efficacy utilizing repeated applications of lower than recommended rates in field and greenhouse studies. Since ivyleaf morningglory is one of the more tolerant species to overtop herbicide applications (28, 29), studies involving the effect of herbicide rate and rate refinement were conducted on this species. Further research on cocklebur and pitted morningglory response to mefluidide (N-[2,4-dimethyl-5-[[trifluoromethyl)sulfonyl]amino]phenyl]acetamide) and acifluorfen combinations was also conducted in field studies.

[1/] Crowder and Harger, unpublished data.

LITERATURE REVIEW

Morningglory species have been classified among the ten worst weeds in field crops (16). Early control of morningglory in soybeans can be achieved by preemergence treatments. However, successful control has been shown to be dependent on the dominant species and rainfall (29). Late germinating morningglories often reduce yields via interference with harvesting (5). Mathis and Oliver (29) concluded that the most effective herbicides in a morningglory control program were those applied postemergence. Since control by specific postemergence herbicides often varies between species, it has become necessary to identify and report control by individual species (4, 27, 29, 47, 53). Smallflower morningglory [*Jacquemontia tamnifolia* (L.) Griseb.] is usually most susceptible to presently available herbicides such as acifluorfen and bentazon [3-isopropyl-1H-2,1,3-benzothiadiazin-4-(3H)-one 2,2 dioxide] while ivyleaf morningglory is usually most tolerant (29). However, Mathis and Oliver (28) reported that bentazon gave satisfactory control of most *Ipomea* species with the exception of ivyleaf. With postemergence herbicide treatments, application should be made in the early stage of development, when susceptibility to the herbicide is often greatest. Tolerance to dinoseb (2-*sec*-butyl-4,6-dinitrophenol) increased with maturity of entireleaf [*Ipomea hederacea* (L.) Jacq var: integriuscula] (2,29). Repeated herbicide applications may be necessary to obtain complete mortality. Mathis and Oliver (29) reported a 13% increase in overall morningglory control with repeated overtop applications of bentazon at 1.12 kg/ha.

Several overtop herbicides are presently available for control of various broadleaf weeds, including morningglory and cocklebur. Within recent years acifluorfen has played a major role in broadleaf weed control programs in soybeans. Acifluorfen is a fast acting compound with maximum activity usually manifested 3 to 7 days after application (7). With the exception of temporary foliar injury, soybeans exhibit good tolerance to acifluorfen (10, 24, 29, 37). Mangeot et al. (24) reported optimal soybean yields when acifluorfen was applied at 0.56 kg/ha postemergence during V1 to V4 (6) development stages. They concluded that the broadest spectrum of weed control resulted when acifluorfen was applied at early stages of weed growth. Effective control of common cocklebur, morningglory, jimsonweed (*Datura stramonium* L.), redroot pigweed (*Amaranthus retroflexus* L.), velvetleaf (*Abutilon theophrasti* Medic.), lambs-quarter (*Chenopodium album* L.), common ragweed (*Ambrosia artemisiifolia* L.), showy crotalaria (*Crotalaria spectabilis* Roth) and various other broadleaf weeds has been reported with overtop applications of acifluorfen (7, 10, 14, 28, 29, 37, 38, 41, 50, 52).

With increased annual grass control using preemergence herbicides in soybeans, release of tolerant broadleaf weeds has created a new problem (7). Under these circumstances, cocklebur and morningglory cause problems to the Southern soybean farmer. Control of common cocklebur less than 15 cm in height has been achieved with applications of acifluorfen ranging from 0.4 kg/ha to 0.9 kg/ha (10, 24, 26, 37, 44). However, in more advanced stages of growth, rates of acifluorfen between 0.9 kg/ha and 1.12 kg/ha are necessary for effective cocklebur control (21, 37). Repeated applications of acifluorfen between 0.2 kg/ha and 0.42 kg/ha applied to 15 to 25 cm cockleburs are sometimes necessary for satisfactory results (37). Even though cocklebur control can be achieved in advanced stages of growth, the broadest spectrum of broadleaf weed control results when acifluorfen is applied at early growth stages.

Two of the most common morningglory species found in Southern soybean fields are I. hederacea and I. lacunosa. Mathis and Oliver (28, 29) postulated that the greater tolerance of ivyleaf and entireleaf morningglory to acifluorfen applications compared to most morningglories might be due to reduced penetration caused by densely pubescent leaf surfaces. In general, most morningglory species are susceptible to applications of acifluorfen (28, 29, 52). Hartnett's (14) results indicate that ivyleaf morningglory is very sensitive to acifluorfen applied in early growth stages. Lee and Oliver (21) controlled 96 and 90% of entireleaf morningglory in the one- and two-leaf stage, respectively, with 0.6 and 0.8 kg/ha of acifluorfen. Hartnett (14) and Mathis (26) achieved excellent control of ivyleaf morningglory using rates between 0.3 and 0.56 kg/ha of acifluorfen applied to plants with less than 8 nodes. However, when morningglory plants are 20 to 45 cm, a 0.56 kg/ha rate or greater is required to obtain acceptable control (14, 28, 38). Rogers and Crawford (44) indicated that rates of 0.28 to 0.56 kg/ha of acifluorfen were required to give 90 to 100% control of ivyleaf and pitted morningglory less than 20 cm long, while rates of 0.84 to 1.12 kg/ha were required to give comparable control of morningglories 20 to 38 cm tall. Mathis and Oliver (29) also achieved greater than 90% control with acifluorfen applied at 0.56 kg/ha at the V2 stage of development in soybeans; however, morningglory regrowth and seedling emergence made a repeated application necessary. Occasionally a high rate of acifluorfen provides equal or less acceptable control than a lower rate (8), which might be dealt with using repeated low rate applications to increase control.

Mefluidide has been reported to control several troublesome weeds in soybeans (11, 33, 43, 45). Rogers and Crawford (43) averaged 40 and 80% control of morningglory and cocklebur, respectively, using mefluidide at rates of .3 to .6 kg/ha. McWhorter and Barrentine (33) achieved 92% control of cocklebur with .56 kg/ha of mefluidide with 0.5% (v/v) nonoxynol [α-(p-nonyl-phenyl)-w-hydroxypoly (oxyethylene)] surfactant in a directed spray.

Additional weeds and/or larger weeds have been controlled in soybeans when mefluidide was used in combination with other herbicides. Hargroder et al. (11) improved control of morningglory and cocklebur when mefluidide was used in combination with bentazon. Rogers et al. (45) used combinations with mefluidide to increase efficacy of bentazon in controlling larger weeds and weeds that were not readily controlled, especially at lower rates.

In order to increase the effective use of acifluorfen for broadleaf weed control in soybeans, tank-mix and sequential applications of acifluorfen with other herbicides have been investigated (12, 13, 18). Harrison et al. (13) conducted studies to define the efficacy and crop tolerance of combinations of acifluorfen and 2,4-DB [4-(2,4-dichlorophenoxy)butyric acid] and to broaden the utility of acifluorfen by increasing the size limits of weeds, particularly cocklebur and ivyleaf morningglory. Acifluorfen at 0.56 kg/ha tank mixed with .034 kg/ha 2,4-DB resulted in acceptable control of 4-8 leaf cocklebur and ivyleaf morningglory with acceptable crop tolerance. Kelley et al. (18) conducted field studies for three years to evaluate tank-mix combinations of acifluorfen and bentazon. Their studies indicated that the addition of bentazon at 0.56 kg/ha to acifluorfen at 0.42 to 0.56 kg/ha consistently provided superior control of mixed weed populations. Hargroder et al. (12) experimented with the grass herbicide mefluidide in combination with sequential applications of acifluorfen. Mefluidide at 0.21 kg/ha followed 1 to 5 days later with 0.42 kg/ha acifluorfen provided consistent control of several weed species, including common cocklebur. Sequential applications of mefluidide and acifluorfen allows the use of the two postemergence herbicides for their label purposes while offering more economical and effective weed control (12).

In development of weed control programs, many factors other than herbicide rate and time of application should be considered. Mitchell and Uniatowski (34) found the most effective weed control system involved acifluorfen combined with cultivation. There is no agreement as to the contribution of surfactants to morningglory control systems using acifluorfen. Parochetti and Harris (38) achieved 95% control of ivyleaf morningglory with up to 8 leaves using 0.3 kg/ha of acifluorfen (2L), without surfactant. However, Wilson and Hines (52) found increased activity of acifluorfen with rates from 0.3 to 1.12 kg/ha with the addition of a surfactant. In a recent study by Lee and Oliver (21), an increase in surfactant improved control of entireleaf morningglory and Texas gourd [Cucurbita texana (A.) Gray] at the 0.3 kg/ha rate of acifluorfen applied two weeks after emergence. However, with a rate of 1.1 kg/ha of acifluorfen, soybean injury was increased when surfactant concentration was increased from 0.5 to 0.75%.

Environmental factors such as relative humidity, temperature, light, and rainfall affect the phytotoxicity of foliar-applied herbicides (9, 35). The immediate aerial environment of susceptible weeds will differ from the average weather conditions and is dependent on the structure of the crop-weed stand. Herbicide penetration can be influenced both physically and physiologically by the relative humidity around the plant (9). Often, if humidity is low, spray droplets will dessicate and penetration will decrease (9). In a physiological sense, relative humidity affects plant water status, stomatal opening and cuticular permeability. In general, high relative humidity before and after spraying is likely to increase the susceptibility of plants to herbicides due to increased penetration (9). In a study by McWhorter and Wills (32) absorption and translocation of ^{14}C-mefluidide was greatest at high temperature and high humidity. Wills (49) found in a cocklebur study involving bentazon absorption and translocation that ^{14}C-bentazon translocation was greatest in cocklebur treated under high soil moisture, high temperature, and high relative humidity.

Temperature conditions before and during application may affect susceptibility of weeds to herbicides (9). Morphological features of the leaf surface, such as cuticle characteristics, and the chemical properties of the spray solution which are important to penetration can be influenced by temperature. Hammerton (9) also stated in his review of environmental influences on herbicides that supra optimal temperatures may reduce herbicide entry by causing water stress, stomatal closure, and rapid dessication of spray droplets. However, McWhorter (31) found that increasing air temperature from 18 to 35C resulted in greater than a four fold increase in translocation of ^{14}C-metriflufen [2-[4-(4-trifluoromethyl]phenoxy)phenoxy]propanoic acid] in johnsongrass [Sorghum halepense (L.) Pers.].

Research has indicated that acifluorfen toxicity is affected by environmental conditions (8, 39, 40, 42, 50). Acifluorfen applied to common cocklebur and common ragweed was more effective at high (85%) RH than that at low (50%) RH, with little effect of day temperatures between 32 and 26C and night temperatures between 22 and 16C (39, 40, 42). Wills (50) found that acifluorfen applied overtop at 0.1 kg/ha controlled showy crotalaria more effectively under high (100%) RH than low (40%) RH after 4 days in controlled environment. Absorption of ^{14}C-acifluorfen into leaves of showy crotalaria 48 h after application was greatest at high temperatures and high relative humidity (50). Translocation of ^{14}C-acifluorfen also followed the same pattern with respect to environment.

Light and temperature affect the nutritional status of the plant, which not only affects absorption and translocation, but simultaneously alters the sensitivity of the plant (35). Light intensity has a direct effect on the cuticle, cutin, and wax as well as stomatal opening, all of which influence rate of herbicide uptake (9).

Rain is an important factor affecting the efficacy of herbicides. If the quantity and intensity of rain following spraying is high, the intercepted spray will be washed from the leaves and reduce its activity (9). However, traces of rain or dew a few hours after spraying could increase penetration by maintaining herbicides in aqueous solution (9). Ritter and Coble (40) examined the effect of 0.6 cm and 1.3 cm rainfall at 30 second and 1 minute intervals, respectively, on acifluorfen toxicity. They concluded that acifluorfen should be on the plant at least 6 hours prior to 1.3 cm of simulated rainfall. Field studies indicated a significant loss of control if acifluorfen was applied within 12 hours before a 2.5 cm rainfall. However, a study conducted by Jolley and Walker (8) indicated excellent control of cocklebur if acifluorfen was applied at least 2 hours prior to rainfall. In their studies with morningglory, excellent control was achieved if rainfall occurred 4 hours after acifluorfen application.

Along with environmental factors, herbicide concentration may play a major role in absorption and translocation in weed species (1, 15, 17, 19). Often the relationship between concentration and penetration of non-contact type herbicides may deviate from linearity. Physiological changes may be induced in the uptake and transport processes at high concentrations, thus altering subsequent penetration (17). In a study conducted by Bahn et al. (1), leaves of yellow nutsedge [Cyperus esculentus (L.)] were pretreated with unlabelled 2,4-D at 0.56, 1.12, and 2.24 kg/ha immediately prior to the addition of a fixed amount of ^{14}C-2,4-D. The percentage of ^{14}C-2,4-D absorbed and translocated tended to decrease with an increase in the rate of pretreatment. In earlier studies with marabu (Dichrostachys nutans), a woody weed found in Cuba, there was no downward translocation of 2,4-D applied 24 hours after a previous application (15). Since phytotoxic amounts were not translocated through living tissues, it was suggested that this was due to the detrimental effects phytotoxic concentrations have on the transport mechanism.

Herbicide absorption by the leaf must occur at a rate that will not damage leaf tissues and thereby impede absorption. With the exception of foliar contact herbicides, translocation of absorbed herbicide, without serious injury to conducting tissues, is necessary if the herbicide is to interfere with normal growth and result in death (9). This aspect is very important in development of effective broadleaf weed control systems.

Toxicity of foliar-applied herbicides often depends on the stage of leaf maturity. McWhorter and Wills (32) stated that ^{14}C-mefluidide absorption was greater in cocklebur when applied to the immature leaves near the apex than to mature leaves near the base of the shoot. Translocation was greater from newly maturing leaves located midway up the stem than from either the more mature leaves at the base or the most immature leaves at the apex. Wills (49) found that greater translocation in cocklebur occurred when ^{14}C-bentazon was applied to the slightly older leaf, fourth down from the apex, compared to the youngest leaves at the apex. Wills found bentazon to be most toxic to common cocklebur under the same environmental conditions that resulted in the greatest distribution of ^{14}C throughout the plant.

Several factors affect the efficacy of acifluorfen as an overtop broadleaf herbicide. Lee and Oliver (20) showed in field studies that time of day of application had no effect on acifluorfen phytotoxicity on morningglory and cocklebur, although dark applications proved to be more effective in controlling I. lacunosa species of morningglory.

Researchers have attempted to correlate selectivity with absorption, translocation and metabolism (3, 22, 23, 25, 32, 41, 46, 48, 49). Wathana et al. (48) found that absorption of 2,4-DB by leaf tissues was much faster in cocklebur than soybean. Cuticular layer differences between these two species was partially responsible for different rates of penetration. They concluded that delayed penetration of the herbicide into treated leaves and the subsequent reduced movement of 2,4-DB to meristematic areas may explain the tolerance of soybean to 2,4-DB.

Selectivity of bentazon and mefluidide to soybeans and cocklebur is unclear. McWhorter and Wills (32) indicated that selectivity of mefluidide was not correlated with variations in absorption and translocation of the herbicide but related more to rate of metabolism in soybean and cocklebur. Bloomberg and Wax (3) found the opposite to be true. Wills (49) correlated the toxicity of bentazon to soybeans and cocklebur with translocation of ^{14}C-bentazon, but Mahoney and Penner (22) found toxicity to be related to the rate of metabolism of bentazon in soybeans and common cocklebur.

Recent research has also been conducted on absorption, translocation, and mode of action of acifluorfen (23, 25, 39, 41, 50). Matsunaka (30) proposed two theories on the mode of action of the photoactivated diphenylethers. One idea involved light energy activation of compounds having 2,4- or 2,4,6- substituents on one benzene ring by converting them into phytotoxic compounds. His alternate proposal was that light acted on the hormonal level causing plants to be more susceptible in the light than in the dark.

Ritter and Coble (41) showed, at all sampling times for common ragweed and common cocklebur, that the amount of ^{14}C-acifluorfen present in the treated leaves was greater than the amount present in other plant parts. Autoradiographs of treated soybeans 48 hours after application showed no movement of ^{14}C-acifluorfen from the treated leaflet. Penetration and limited translocation of acifluorfen occurred in ragweed and cocklebur. Only acropetal movement occurred once the ^{14}C-acifluorfen reached the stem. Greater penetration and translocation in susceptible weed species compared to soybeans may explain acifluorfen's mechanism of selectivity. Mangeot and Rieck (23) found translocation of small amounts of ^{14}C-acifluorfen to the stem and plant shoot of soybeans above the treated leaves 24 hours after application. However, visual injury was observed only on the treated leaves.

Using thin layer chromatography with acifluorfen markers, Ritter and Coble (41) found that after 1 week soybeans had metabolized more of the parent herbicide than cocklebur or ragweed. They concluded that greater penetration and translocation coupled with slower metabolism by common ragweed and common cocklebur contributed to their susceptibility to acifluorfen. These findings are also in agreement with those of Mangeot and Rieck (23). In studies with ^{14}C-acifluorfen on soybeans, they found that the percentage of the activity in the aqueous extracts that cochromatographed with acifluorfen decreased in the leaflets with longer exposure times, while the data for the shoot above showed increased acifluorfen.

Mangeot et al. (25) also evaluated ^{14}C-acifluorfen translocation and absorption in ivyleaf morningglory. Plants with second alternate leaves were treated on the first alternate leaf. Treated leaves and meristems above the treated leaves were dead within two days after treatment. Translocation of ^{14}C in ivyleaf morningglory was mainly acropetal and concentrated in the meristematic tissue. Soybeans retained the radioactivity at sites of application. Significantly greater ^{14}C was extracted from the treated leaves of soybeans than morningglories at 2 and 4 days after application. This difference was accounted for by the amount of ^{14}C translocated out of the treated leaf in morningglory. The metabolism study indicated that ^{14}C-acifluorfen was the major ^{14}C- material translocated from the point of application in ivyleaf morningglory.

MANUSCRIPT I

REPEATED LOW RATES OF ACIFLUORFEN FOR IVYLEAF MORNINGGLORY CONTROL[1]

S. H. CROWDER, T. R. HARGER, AND J. W. SHREFLER[2]

ABSTRACT. Field and greenhouse studies were conducted in 1981 and 1982 to evaluate acifluorfen [5-[2-chloro-4-trifluoromethyl) phenoxy]-2-nitrobenzoic acid] efficacy for control of ivyleaf morningglory [*Ipomea hederacea* (L.) Jacq. var: hederacea] in soybeans [*Glycine max* (L.) Merr.] utilizing repeated low rate applications compared to single applications of recommended rates. In the greenhouse studies, two applications of 0.2 kg/ha acifluorfen, applied 3 days apart, controlled 80% of the ivyleaf morningglory which was significantly more effective than a single application of 0.4 kg/ha. An increase in the single application rate from 0.2 to 0.4 kg/ha decreased morningglory control. In 1981 field studies, two applications of 0.2 kg/ha acifluorfen provided increased control compared to a single application of 0.6 kg/ha in 1981. These treatments were equally effective in the 1982 studies as indicated by visual ratings and fresh weight determinations. Fresh weight of treated morningglory was influenced by acifluorfen treatments

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[1] Received for publication . These data are from the Ph.D. dissertation of the first author.

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in a manner similar to visual ratings and detected the presence of regrowth at plant nodes.

Additional index words. *Glycine max*, *Ipomea hederacea*, rate response, morningglory regrowth.

INTRODUCTION

One of the most troublesome broadleaf weeds found in Southern soybean fields is morningglory (*Ipomea* spp.). Early season control of morningglory in soybeans can be achieved by preemergence treatments. However, the level of control is dependent on the dominant species and rainfall (11). Ivyleaf and pitted morningglory [*Ipomea lacunosa* (L.)] potentially produce greater biomass per plant than other morningglory species grown under the same conditions (3). Season long competition between morningglory and soybeans may reduce yield as much as 70% (12,17).

Control by specific postemergence herbicides often varies between morningglory species, necessitating correct identification and delineation of individual species in weed control reports (2,9,11,16,19). Small flower morningglory [*Jacquemontia tamnifolia* (L.) Griseb] is usually most susceptible to presently available herbicides while ivyleaf morningglory is usually most tolerant (11). With postemergence herbicide treatments, application should be made in the early stage of morningglory development, when susceptibility to the herbicide is often greatest. Tolerance to dinoseb (2-*sec*-butyl-4,6-dinitrophenol) increased with increased maturity of entire leaf morningglory [*Ipomea hederacea* (L.) Jacq. var: integriuscula] (1,11). The density of foliage growth in later stages causes difficulty in achieving complete coverage with herbicide sprays.

Several overtop herbicides are presently available for control of morningglory species. Mathis and Oliver (10) reported that bentazon [3-isopropyl-1H-2,1,3-benzothiadiazin-4-(3H)-one 2,2 dioxide] gave satisfactory control of most Ipomea species with the exception of ivyleaf morningglory. Acifluorfen also selectively controls broadleaf weeds when applied postemergence in soybeans (5,7,11,13,14). Mangeot et al. (7) reported optimal soybean yields when acifluorfen was applied at 0.56 kg/ha postemergence during V1 to V4 (4) development stages. In general, most morningglory species are susceptible to applications of acifluorfen (10,11,18). Hartnett (6) and Mathis (8) achieved excellent control of ivyleaf morningglory using rates between 0.3 and 0.56 kg/ha of acifluorfen applied to plants with less than 8 nodes. Rogers and Crawford (15) indicated that rates of 0.28 to 0.56 kg/ha of acifluorfen were required to give 90 to 100% control of ivyleaf and pitted morningglory less than 20cm long, while rates of 0.84 to 1.12 kg/ha were required to give comparable control of morningglories 20 to 38cm long.

Occasionally a high rate of acifluorfen has resulted in equal or less acceptable control than a lower rate.[3] Repeated low rate herbicide applications may be necessary to obtain complete mortality. Mathis and Oliver (11) achieved greater than 90% control with acifluorfen applied at 0.56 kg/ha at the V2 stage of development in soybeans; however, morningglory regrowth and seedling emergence made a repeated application necessary. Overton et al. (13) found that repeated applications of acifluorfen between 0.2 kg/ha and 0.42 kg/ha are sometimes necessary to control 15 to 25cm cocklebur (Xanthium pennsylvanicum Wallr.). Mathis

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[3] Crowder and Harger, unpublished data

and Oliver (11) also reported a 13% increase in overall morningglory control with repeated overtop applications of bentazon at 1.12 kg/ha.

With increasing herbicide cost, development of a morningglory control program utilizing minimal herbicide while maintaining adequate morningglory control would be economically important to the soybean producer. The objective of this research was to evaluate control of ivyleaf morningglory utilizing repeated applications of lower than recommended rates of acifluorfen in field and greenhouse studies.

MATERIALS AND METHODS

Greenhouse studies. Ivyleaf morningglory seeds were planted in the greenhouse in standard six inch styrofoam pots containing a mixture of Olivier silt loam (pH=6.2, O.M.=.58%), sand, and coarse vermiculite (1:1:1, v/v/v). Seeds were collected locally and planted in soil maintained at field capacity.

Greenhouse temperature and relative humidity were maintained at 40/20 ± 3 C and 40/100%, respectively, during day/night periods. Natural light was supplemented with metal halide lighting in morning and evening hours to establish a daylength of 14 h. The photosynthetic flux densities measured at plant height varied from 500 to 1400 $\mu Em^{-2}s^{-1}$ on cloudy and sunny days, respectively.

One week after planting, seedlings were thinned to three plants per pot. Approximately two weeks later, when plants had three to six true leaves, the sodium salt of acifluorfen with surfactant was applied using a compressed-air greenhouse moving belt sprayer equipped with a 80015E even-spray nozzle[4] delivering approximately 200L/ha at a pressure of

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[4] Nozzles used in these studies were a product of the Spraying Systems Co.

1.83 kg/cm^2. Treatments consisted of single applications of acifluorfen applied at 0.2, 0.4, and 0.6 kg/ha active ingredient, respectively, plus two treatments of two and three repeated applications of acifluorfen at 0.2 kg/ha, for a total of 0.4 and 0.6 kg/ha, respectively. All repeated applications were made at three-day intervals following the first application. The experiment was conducted twice in a completely random design with four replications. Each replication consisted of a single greenhouse pot containing three plants. Weed control was visually estimated two weeks after initial herbicide application, of both single and repeated treatments. After rating, plants were excised at the soil surface and fresh weight determined.

Field studies. The research was conducted at the Ben Hur Research Farm at Baton Rouge, Louisiana on a Mhoon silty clay loam soil with 1.2% organic matter and a pH of 6.6. The test area received 140 and 280 kg/ha of 0-24-24 fertilizer in 1981 and 1982, respectively, based on soil test recommendations for soybeans. An experimental area was selected with a natural infestation of ivyleaf morningglory present. Conventional cultural practices were utilized in field preparation. In 1982 an application of 2.2 kg/ha of metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl) acetamide] was applied over the test area to control weeds other than morningglory. 'Forrest' soybeans were planted conventionally in 82 cm rows at a seeding rate of 40 seeds per meter.

The experiment was arranged in a randomized complete block design with four replications. Herbicides were applied to a 5 by 2 meter area including two rows of soybeans bounded on either side by two untreated rows for comparison purposes during evaluation.

Approximately three weeks after planting in 1981 and 1982, herbicide treatments were applied with a hand held CO_2 pressurized broadcast boom using five 8003 nozzles delivering 200L/ha of spray solution. In 1981, a single application of acifluorfen at 0.6 kg/ha was compared to two and three applications of 0.2 kg/ha for a total of 0.4 and 0.6 kg/ha, respectively. In 1982, field treatments were identical to those described in the greenhouse experiments.

Field studies were conducted twice in 1981 and in 1982. In 1981, herbicides were applied when morningglory plants had four to seven true leaves in one experiment and ten to twelve true leaves in the second field test. In 1982, the morningglory plants had seven to ten true leaves in both experiments at the time of application. In 1981, the study area received 56.16 cm of precipitation during the growing season from May through August compared to 36.20 cm in 1982. Rainfall amounts were recorded 12 days before and after initial acifluorfen applications in all field experiments (Table 1).

Visual percent control ratings were made at approximately twenty-one days after initial herbicide application in 1981 and at ten and twenty-one days after initial herbicide application of both single and repeated herbicide treatments in 1982. After the second rating in 1982, three representative plants tagged at application in each replication were excised at the soil surface and fresh weight determined.

Statistical analysis. Results of experiments conducted twice are presented as the mean of both studies. Both percent control and fresh weight data in field and greenhouse studies were subject to analysis of variance and means separation using Duncan's multiple range test.

Table 1. Rainfall data 12 days before and after initial postemergence applications of acifluorfen in 1981 and 1982.

Planting Date	Days after application 12-10	9-7	6-4	3-1	Application Date	Days after application 0-3	4-6	7-9	10-12
	-----------cm----------					----------cm-----------			
5-12-81	4.65	0.25	7.47	0.94	6-11-81	2.34	0	0	4.39
7-24-81	0	0.10	0	0	8-26-81	0.08	0.97	4.65	0.03
5-17-82	0	0	0.18	0	6-08-82	0	1.85	2.77	0
6-23-82	0	0	1.07	1.78	7-13-82	0.05	0.05	0.33	0.11

RESULTS AND DISCUSSION

Greenhouse studies. Since percent control and fresh weight measurements indicated similar results in greenhouse experiments, only fresh weight data are presented. However, differences in response to acifluorfen applications occurred between experiments. In the combined analysis, fresh weight of plants treated with three applications of 0.2 kg/ha acifluorfen were not different from those treated with one application of 0.6 kg/ha (Figure 1). Both treatments achieved greater than 90% reduction in fresh weight of ivyleaf morningglory under greenhouse conditions. Two applications of 0.2 kg/ha were more effective on ivyleaf morningglory than a single application of 0.4 kg/ha. The single application of 0.2 kg/ha rate of acifluorfen reduced fresh weight of the morningglory more than a single application of 0.4 kg/ha, but not more than the repeated applications of 0.2 kg/ha. This decrease in morningglory control as rates increased from 0.2 kg/ha to 0.4 kg/ha of aciflurofen, was only observed in one experiment, although such results have been observed in previous field studies involving several rates of acifluorfen.[3] The single application of 0.4 kg/ha resulted in higher fresh weight than any acifluorfen treatment. Often fresh weight measurements were indicative of the regrowth from the nodes of the morningglory.

Field Studies. In the combined analysis of two field studies in 1981, two and three repeated low rate applications of 0.2 kg/ha acifluorfen increased control of the ivyleaf morningglory over that of a single application of 0.6 kg/ha (Figure 2). Two applications of 0.2 kg/ha not only improved control over the single application of 0.6 kg/ha but required only two-thirds of the total amount of herbicide.

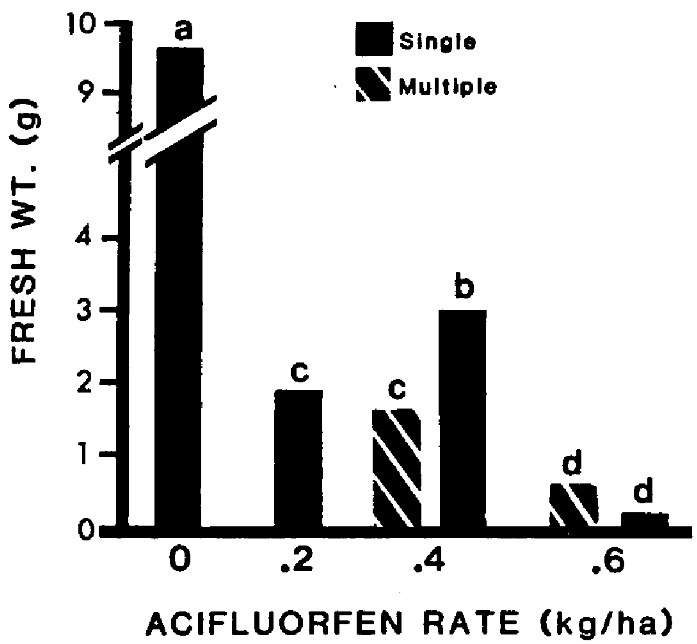

Figure 1. Influence of repeated applications of acifluorfen at 0.2 kg/ha (▚) compared to single applications (■) on grams of fresh weight of ivyleaf morningglory in greenhouse experiments. Columns specified by the same letter are not significantly different at alpha = .05 by Duncan's multiple range test.

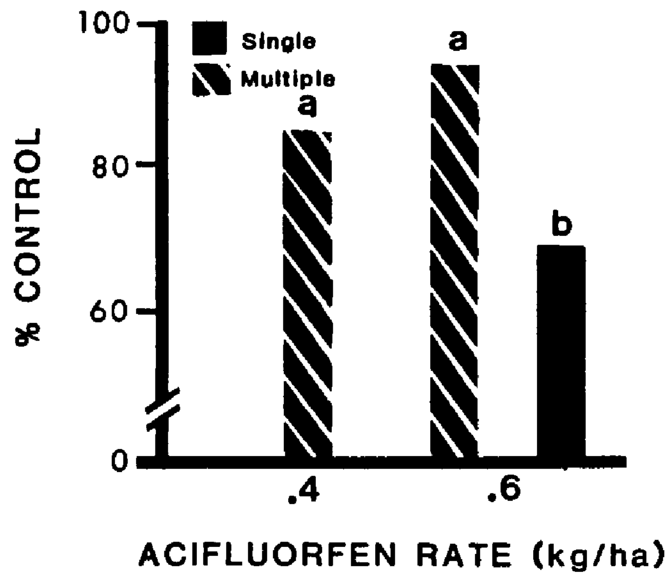

Figure 2. Influence of repeated applications of acifluorfen at 0.2 kg/ha (▧) compared to single applications (■) on control of ivyleaf morningglory in 1981 field experiments. Columns specified by the same letter are not significantly different at alpha = .05 by Duncan's multiple range test.

In addition to the visual control ratings in the 1982 field studies, three representative plants in each treated plot were labelled when treated and used for fresh weight measurements. Since visual control ratings estimated at ten and twenty-one days after application revealed similar results, only ratings made ten days after application are presented (Figure 3). Acifluorfen applied as two applications of 0.2 kg/ha controlled 90% of the ivyleaf morningglory. Percent control was not significantly improved with the 0.6 kg/ha rate applied either as single or multiple applications of 0.2 kg/ha acifluorfen. Two applications of 0.2 kg/ha were better for ivyleaf morningglory control than the single application of 0.4 kg/ha. Differences in percent control and fresh weight of treated morningglory were detected between the two 1982 field experiments. The initial experiment in May, 1982, did not received rain during the three week period prior to acifluorfen application, causing control to be lower than expected. The second experiment was conducted in July, 1982, when sufficient moisture was available for plant growth.

No differences in fresh weight of the marked plants were detected between the single applications and the repeated low rate applications of 0.4 and 0.6 kg/ha acifluorfen treatments (Figure 4). However, the three repeated applications of 0.2 kg/ha treatment resulted in significantly less fresh weight than the single application of 0.4 kg/ha.

In both the 1981 and 1982 field studies, repeated low rate applications of 0.2 kg/ha acifluorfen improved control of ivyleaf morningglory without significant injury to the soybeans. Two applications of 0.2 kg/ha acifluorfen provided increased control over

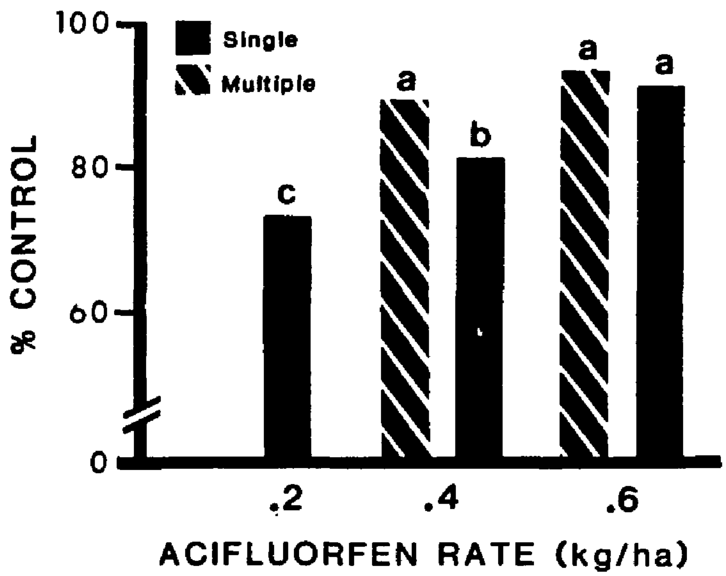

Figure 3. Influence of repeated applications of acifluorfen at 0.2 kg/ha (◣) compared to single applications (■) on control of ivyleaf morningglory in 1982 field experiments. Columns specified by the same letter are not significantly different at alpha = .05 by Duncan's multiple range test.

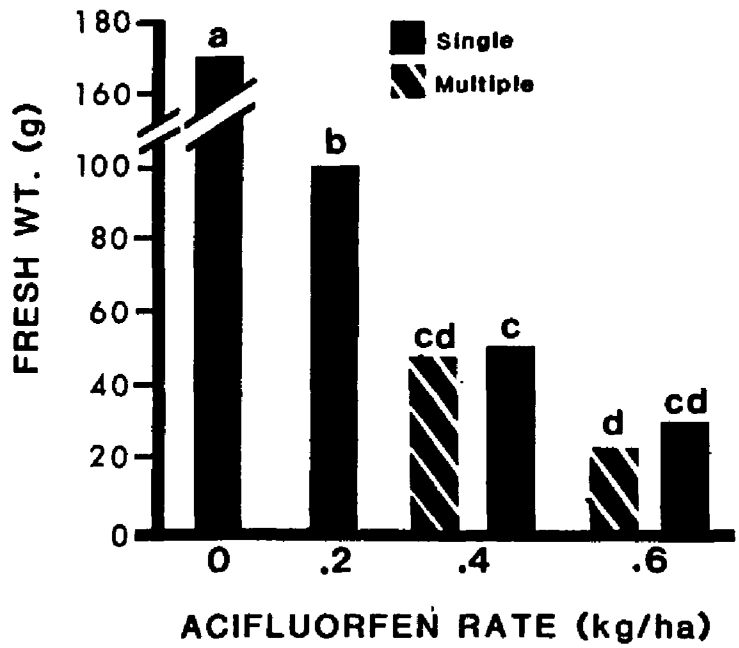

Figure 4. Influence of repeated applications of acifluorfen at 0.2 kg/ha (▧) compared to single applications (■) on grams of fresh weight of ivyleaf morningglory in 1982 field experiments. Columns specified by the same letter are not significantly different at alpha = .05 by Duncan's multiple range test.

the single application of 0.6 kg/ha. Several researchers (11,13) have demonstrated improved control using repeated applications of acifluorfen. It is possible that lower rates of herbicide results in decreased initial injury of treated leaf tissue, allowing greater movement of the herbicide into stem tissue and preventing node regrowth. Using repeated low rate programs on ivyleaf morningglory (11) may be necessary to obtain season long control with acifluorfen in soybeans. A better understanding of environmental conditions conduscive to more dramatic plant response is needed for practical application of this technique.

ACKNOWLEDGEMENTS

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MANUSCRIPT II

EFFECT OF HERBICIDE RATE OF APPLICATION ON THE TRANSLOCATION AND TOXICITY OF ACIFLUORFEN TO MORNINGGLORY[1]

S. H. CROWDER, T. R. HARGER, AND J. P. GEAGHAN[2]

ABSTRACT. To study the effect of acifluorfen (5-[2-chloro-4-trifluormethyl)phenoxy]-2-nitrobenzoic acid) rate on herbicidal efficacy of ivyleaf morningglory [*Ipomea hederacea* (L.) Jacq. var: hederacea], field and greenhouse studies were conducted using rates from .07 to 2.4 kg/ha. Analysis of covariance was conducted on the fresh weight, translocation and percent control data of ivyleaf morningglory. Where possible, the statistical model included terms up to the fourth order polynomial response. Percent control evaluations in both greenhouse and field experiments required a cubic term in the line equation to explain the curvilinear response. Similar results were obtained in the analysis of the fresh weight measurements. Effectiveness of the acifluorfen treatments in control of the ivyleaf morningglory was different between field experiments. Since regrowth at the morningglory nodes occurred at the higher rates, translocation studies were conducted to determine the effect of herbicide rate of application on translocation of ^{14}C-acifluorfen into the stem. Field rates of 0.15, 0.6, and 1.2 kg/ha of ^{14}C-acifluorfen were applied to morningglory leaves and analyzed 24,

[1] Received for publication . These data are from the Ph.D. dissertation of the first author.

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48 and 72 hours after application. In the stem section, including the nodes of the treated leaves, no differences occurred in ^{14}C translocation between harvest periods. However, in the analysis of the remainder of the stem, in the amount of ^{14}C label translocated differed between harvest periods. In a secondary study, rates ranging from 0.15 to 1.2 kg/ha of ^{14}C-acifluorfen were applied to ivyleaf morningglory to define the effect of herbicide rate of application on translocation in the stem. The amount of ^{14}C translocated increased linearly with increasing field rates of ^{14}C-acifluorfen applied to the leaves. Acifluorfen application rate is not a critical factor affecting the ability of treated plants to translocate ^{14}C-acifluorfen.

Additional index words. *Ipomea hederacea*, rate response, morningglory regrowth.

INTRODUCTION

One of the most troublesome broadleaf weeds found in Southern soybean [*Glycine max* (L.) Merr.] fields is morningglory (*Ipomea spp*.). Effective, yet expensive, postemergence herbicides are presently available for control of specific broadleaf weeds. With increasing cost of herbicides, development of a morningglory control program utilizing less herbicide and maintaining effective control would be an economical alternative for the soybean producer.

Control of morningglory by specific postemergence herbicides often varies between species, necessitating identification of individual species (2,11,13,21,25). Small flower morningglory [*Jacquemontia tamnifolia* (L.) Griseb] is usually most susceptible to bentazon [3-isopropyl-1H-2,1,3-benzothiadiazin-4-(3H)-one 2,2 dioxide] while ivyleaf morningglory is usually most tolerant (11). Postemergence herbicide applications should be made during the early stage of morningglory development, when susceptibility of the herbicide is greatest. Foliage growth of morningglory in later stages causes difficulty in achieving complete coverage with herbicide sprays. Ivyleaf and pitted morningglory [*Ipomea lacunosa* (L.)] produce the highest biomass per plant compared to other morningglory species grown under the same conditions (3). Season-long competition with soybeans may reduce yield as much as 70% (14,23).

Several overtop herbicides are presently available for control of morningglory species. Mathis and Oliver (13) reported that bentazon gave satisfactory control of most *Ipomea spp*. with the exception of ivyleaf. Acifluorfen also selectively controls broadleaf weeds when applied postemergence in soybeans (15,16). In general, most morningglory species are susceptible to applications of acifluorfen (12,13,24), however some tolerance is exhibited by ivyleaf (13). Hartnett (7) and Mathis (10) achieved excellent control of ivyleaf using rates between 0.3 and 0.56 kg/ha of acifluorfen applied to plants with less than 8 nodes. Rogers and Crawford (20) indicated that rates of 0.28 to 0.56 kg/ha of acifluorfen were required to give 90 to 100% control of ivyleaf and pitted morningglory less than 20 cm long, while rates of 0.84 to 1.12 kg/ha were required to give comparable control of morningglories 20 to 38 cm long. Mathis and Oliver (13) also achieved greater than 90% control with acifluorfen applied at 0.56 kg/ha at the V2 (4) stage of development in soybeans; however, morningglory regrowth and seedling emergence made a repeated application necessary.

Research has shown that acifluorfen toxicity is affected by environmental factors such as relative humidity, temperature, light, and rainfall (5,17,18,19,22). Along with environmental factors, herbicide concentration may play a major role in absorption and translocation in weed species (1,8,9). Occasionally a high rate of acifluorfen has resulted in equal or less acceptable control than a lower rate.[3] Often the relationship between concentration and penetration of foliar absorbed, translocatable herbicides may deviate from linearity. Physiological changes may be induced in the uptake and transport processes at high concentrations, thus altering subsequent penetration (9). In a study conducted by Bahn et. al. (1), leaves of yellow nutsedge [Cyperus esculentus (L.)] were pretreated with unlabelled 2,4-D [(2,4-dichlorophenoxy)acetic acid] at 0.56, 1.12, and 2.24 kg/ha immediately prior to the addition of a fixed amount of ^{14}C-2,4-D. The percentage of ^{14}C-2,4-D absorbed and translocated tended to decrease with an increase in the rate of pretreatment. In earlier studies in marabu (Dichrostachys nutans), a woody weed found in Cuba, there was no downward translocation of 2,4-D applied 24 hours after a previous application (8). Since a significant quantity of 2,4-D was not translocated through living tissues, detrimental effects on the transport mechanism or cell membranes, may have occurred.

In a translocation study conducted by Mangeot[4], ^{14}C-acifluorfen was detected in all plant parts of ivyleaf morningglory 6 h after foliar application. The percent of ^{14}C-acifluorfen in the untreated leaves increased with time and reached a maximum after 16 h. The subsequent metabolism study with this species indicated that ^{14}C-acifluorfen was

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[3] Crowder and Harger, unpublished data.

[4] Mangeot, B. L., Ph.D. Dissertation, University of Kentucky, Lexington

the major ^{14}C-material translocated from the point of application. Herbicide absorption by the leaf must occur at a rate that will not damage leaf tissues and thereby limit translocation. With the exception of foliar contact herbicides, translocation of absorbed herbicide, without serious injury to conducting tissues, is necessary if the herbicide is to interfere with normal growth and result in death of untreated tissue (6).

The objectives of this research were (a) to study the effect of acifluorfen rate on morningglory control in field and greenhouse studies, and (b) to study the effect of acifluorfen rate on translocation of ^{14}C-acifluorfen into the stem of ivyleaf morningglory.

MATERIALS AND METHODS

Herbicide Rate Studies. Ivyleaf morningglory plants were treated with the sodium-salt of acifluorfen formulated with surfactant, at rates of 0, 0.07, 0.15, 0.3, 0.6, 0.9, 1.2, 1.8, and 2.4 kg/ha active ingredient. For greenhouse experiments, plants were grown from locally collected seed in six-inch styrofoam pots containing a mixture of Olivier silt loam (pH=6.2, O.M.=.58%), sand, and coarse vermiculite (1:1:1, v/v/v). Pots were perforated for drainage and maintained at field capacity.

One week after planting, seedlings were thinned to three plants in each pot. Herbicide treatments were applied using a compressed-air, moving belt sprayer equipped with one 80015E even fan nozzle[5] delivering 200L/ha spray volume at a pressure of 1.83 kg/cm^2 approximately two

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[5] Nozzles used in these studies were a product of the Spraying Systems Co.

weeks later when plants had developed four to eight fully expanded leaves.

During the course of these studies, greenhouse temperatures and relative humidities were 40/20 ± 3C and 40/100%, respectively, during day/night periods. Natural light was supplemented with metal halide lighting in morning and afternoon hours to establish a daylength of 14 h. The photosynthetic photon flux densities measured at plant height varied from 500 to 1,400 $\mu Em^{-2}\ s^{-1}$ on cloudy and sunny days, respectively.

The experiment was conducted as a completely random design with four replications, each experimental unit comsisting of a single greenhouse pot containing three plants. Percent control ratings were visually estimated three weeks after herbicide application. After rating, plants were cut at the soil surface and total fresh weight per pot determined.

Field studies to supplement greenhouse research were conducted at the Ben Hur Research Farm at Baton Rouge, Louisiana on a Mhoon silty clay loam soil (pH=6.6, O.M.=1.2%). The test area had received 280 kg/ha of 0-24-24 fertilizer based on soil test recommendations for soybeans. Experimental areas were selected with a natural infestation of ivyleaf morningglory present. An application of 2.2 kg/ha of metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1= methylethyl) acetamide] was applied over the test area. 'Forrest' soybeans were planted using conventional seedbed preparation on 82 cm rows at a seeding rate of 40 seeds per meter.

Approximately three weeks after planting, herbicide treatments were applied to field plots with a hand-held, CO_2 pressurized broadcast boom with five 8003 flat fan nozzles delivering 200L/ha of spray solution at a pressure of 2.25 kg/cm. Morningglory plants had developed seven to ten true leaves at the time of acifluorfen application. During the growing season from May thru August, 36.20 cm of rain was recorded. Rainfall amounts were recorded 12 days before and after acifluorfen application in both field experiments (Table 1).

The experiment was designed as a randomized complete block with four replications. The treated plots measured 5 by 2 meters including two rows of soybeans. Each treated area was bounded on either side by two untreated rows for comparison purposes. Percent control evaluations were estimated approximately ten and twenty-one days after herbicide application. After the second evaluation, three representative plants tagged at the time of acifluorfen application were cut at the soil surface and fresh weight determined immediately in the field.

Translocation Studies. Studies were conducted under both greenhouse and field conditions to determine the effect of acifluorfen rate on translocation of ^{14}C-acifluorfen into the stem of ivyleaf morningglory. Experiments were arranged as completely random designs with three replications, each representing a single plant. The initial greenhouse experiment was conducted to examine translocation of ^{14}C-acifluorfen over time, with respect to herbicide rate. Further translocation studies under both greenhouse and field conditions were initiated to quantitate the effect of herbicide rate on translocation into the stem over a single time period. In both field and greenhouse studies, three week old plants were treated with ^{14}C-acifluorfen on the sixth and seventh fully expanded leaves from the base of the plant. Treated plants had runners 12 to 24 cm long with 8 to 12 leaves per

Table 1. Rainfall data 12 days before and after postemergence applications of acifluorfen in 1982 field herbicide rate studies.

Planting Date	Days before application 12-10	9-7	6-4	3-1	Application Date	Days after application 0-3	4-6	7-9	10-12
	---------- cm --------					---------- cm --------			
5-17-82	0	0	0.18	0	6-08-82	0	1.85	2.77	0
6-23-82	0	0	1.07	1.78	7-13-82	0.05	0.51	0.33	0.11

plant. The ^{14}C-acifluorfen was applied with a pipetman^{R} (Gilson) to a 2 by 1 cm area along the midvein on the adaxial surface of each of the two treated leaves. A 0.25% solution of a non-ionic surfactant in water was sprayed as a mist on the leaves using an atomizer prior to the ^{14}C-acifluorfen application. Application of the ^{14}C-acifluorfen was made dropwise and evenly spread over the designated area using the side of the disposable tip of the pipetman. Rates were calculated based on the amount of herbicide that would be applied to a horizontal leaf surface per 2 cm^2 area if exposed to a broadcast application. The ^{14}C-acifluorfen was uniformly phenyl-ring-labelled in the nitro ring and had a specific activity of 3.32 μCi/mg active ingredient.

The initial experiment consisted of application of ^{14}C-acifluorfen to ivyleaf morningglory representing field herbicide rates of 0.15, 0.6, and 1.2 kg/ha. The working ^{14}C-acifluorfen solution contained 0.025 μCi in 5 μl water which equaled 0.15 kg/ha of acifluorfen on the 2 cm^2 area. The higher herbicide rates were obtained by increasing the volume of ^{14}C-solution applied to the treated area. At higher volumes, the solution was applied and allowed to dry in several small increments to prevent loss of the ^{14}C-solution by runoff from the leaf surface. Treated plants were harvested at 24, 48 and 72 h after application.

The second translocation study conducted under both greenhouse and field conditions, consisted of application of ^{14}C-acifluorfen to ivyleaf morningglory, representing field herbicide rates of 0.15, 0.3, 0.6, 0.9, and 1.2 kg/ha. The working ^{14}C-acifluorfen solution in this greenhouse and field study contained 0.019 μCi in 5 μl water which equaled the field rate of 0.3 kg/ha of acifluorfen.

At the time of application of the ^{14}C-acifluorfen in the greenhouse studies, the temperature was 25 C and the relative humidity approximately 75%. During the 3-day period following application, temperatures and relative humidities were 30/18 ± 3 C and 60/100% respectively, during day/night periods.

In the field study, a natural infestation of ivyleaf morningglory, comparable in size to plants used in the greenhouse, were selected in a recently tilled area. Identical materials and methods, including the five prescribed ^{14}C-acifluorfen dosage rates used in the second greenhouse study, were utilized in the field translocation study. However, temperature and relative humidity during field application of the ^{14}C-acifluorfen were somewhat higher than under greenhouse conditions. At application the field temperature was 31 C and the relative humidity was 100%. During the course of the experiment, temperatures and relative humidities were 34/25 ± 3 C and 60/100%, respectively, during day/night periods. Plants were harvested 48 h after application and prepared for analysis.

To quantify ^{14}C movement plants were harvested with as much root system intact as possible after the established time interval. After rinsing the roots, each plant was cut into six sections; the two treated leaves (petiole cut 1 cm from node), leaves and stem from 1 cm above the uppermost treated leaf, stem 1 cm above the node of the upper treated leaf to approximately 1 cm below the node of the lower treated leaf, stem 1 cm below the node of the lower treated leaf, the leaves and petioles from the lower stem, and the roots. All plant parts were frozen overnight at -14 C and lypholized for approximately 54 h. After remaining in room conditions overnight, dry weight of the plant sections were recorded. Afterwards the whole plants were combusted in oxygen with a biological oxidizer (Harvey BMO) and $^{14}CO_2$ was trapped in 15 ml of commercially prepared scintillation cocktail, Scintisorb-C^R (Isolab). Radioactivity was quantitated by a liquid scintillation spectrometer (Beckman LS-250). Counts per minute were corrected for counting and combustion efficiency and results expressed as micrograms of ^{14}C-acifluorfen equivalent based on the specific activity of the ^{14}C-acifluorfen applied.

Statistical Analysis. Data were subjected to standard analysis of covariance. Aciflurofen rate treatments were the independent variable and percent control and fresh weight measurements were the dependent variables in greenhouse and field rate studies. Treatments were analyzed as a polynominal series. In the translocation studies the micrograms of ^{14}C-acifluorfen active ingredient translocated into the stem was the dependent variable. The statistical model utilized included terms up to the quartic level in most cases. The results of the polynomial responses were compared graphically.

RESULTS AND DISCUSSION

Herbicide Rate Studies. In the greenhouse experiments, visual control of ivyleaf morningglory increased rapidly as the rate of acifluorfen increased from 0.07 to 0.9 kg/ha (Figure 1). In the analysis of covariance, curves constructed from the two experiments had different intercepts but were not different in shape (probability of a $>$ F $<$ .03). Acifluorfen activity in experiment 1 resulted in maximum control of ivyleaf morningglory at 0.6 kg/ha. However, in experiment 2, 100% control was not achieved until the acifluorfen was applied at 0.9 kg/ha. At rates greater than 0.9 kg/ha, control decreased below 100%

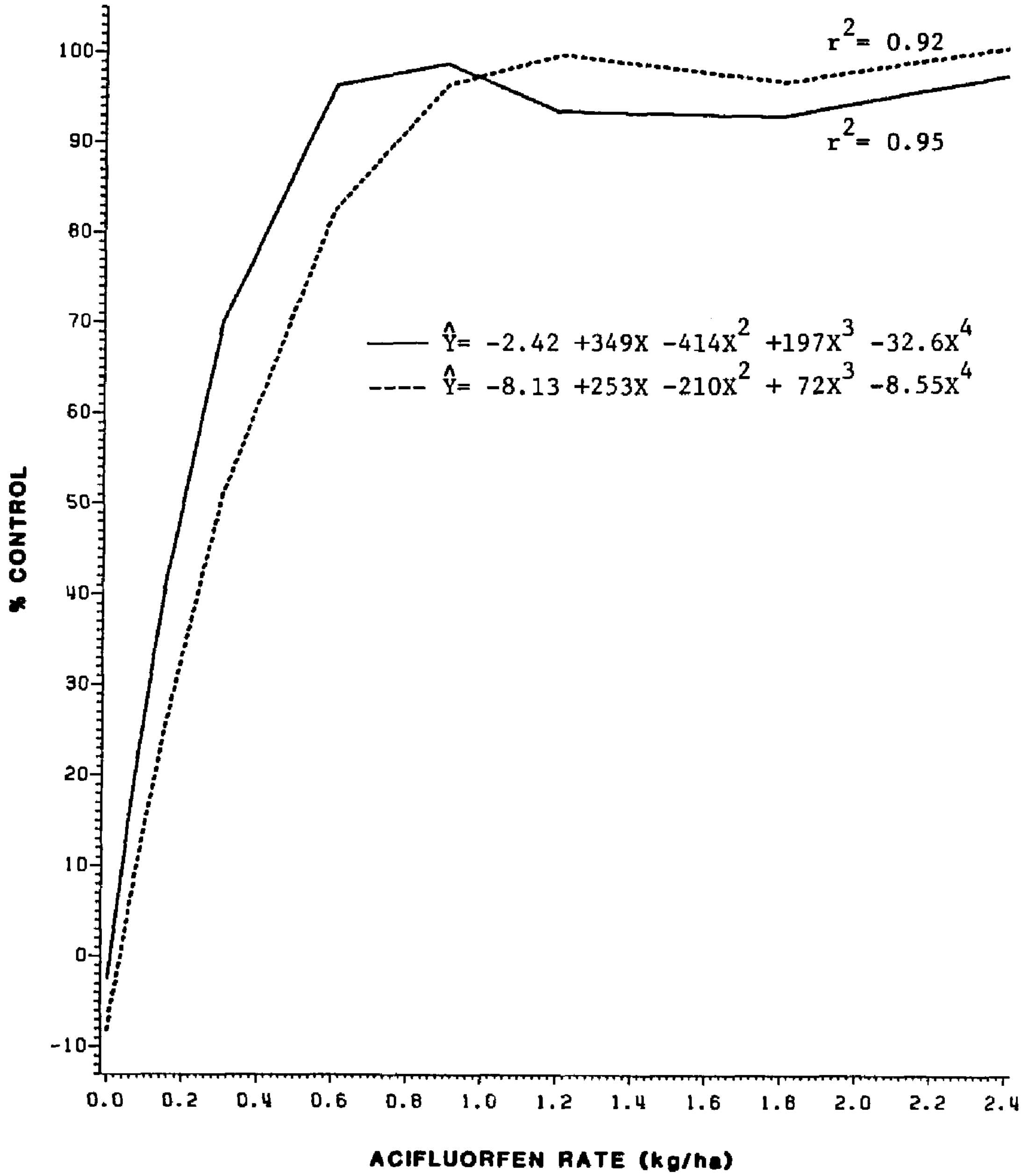

Figure 1. Influence of increasing acifluorfen rate on control of ivyleaf morningglory in greenhouse studies. Response of experiment 1 (——), Response of experiment 2 (----).

due to recovery of the treated plants by regrowth at the axillary buds of the lower nodes (Table 2) rather than a lack of phytoxicity to tissue actually treated with the acifluorfen. This suggests that translocation is limited at high application rates preventing control from reaching 100%. Fresh weight data measured from the same experiments also reflected the response to acifluorfen and the regrowth at higher rates (Figure 2). Polynomial equations, derived by the combined analysis of both experiments, had prediction coeffecients (r^2 values) of 93 and 77 percent for visual rating and fresh weight data, respectively, indicating that they were acceptable predictions of acifluorfen activity under greenhouse conditions.

In the analysis of the field rate studies, there was a significant interaction at the .05 level between field trials in both percent control and fresh weight evaluations. At twenty-one days after application, the percent control response to increased rates of acifluorfen recorded after regrowth of the morningglory had initiated, was significant as a third order polynomial. The effectiveness of the acifluorfen treatments varied considerably between the field trials (Figure 3). The environmental conditions during the first experiment were not conducive to maximum herbicide activity. The experimental area had not received rain for three weeks prior to the acifluorfen applications. Under conditions of adequate soil moisture and high relative humidity at application in experiment 2, improved control was achieved at the lower herbicide rates which was similar to the response under greenhouse conditions.

Prior research by Ritter and Coble (18) and Wills (21) emphasized the importance of high humidity and temperature to acifluorfen toxicity.

Table 2. Effect of increasing rates of acifluorfen on regrowth at the axillary buds of ivyleaf morningglory in greenhouse rate studies.

Treatment	Rate	Regrowth[a]	Highest Node of Regrowth[b]
	(kg/ha)	(%)	(no.)
Acifluorfen	0.07	-[c]	-
Acifluorfen	0.15	-	-
Acifluorfen	0.3	50	2
Acifluorfen	0.6	63	3
Acifluorfen	0.9	25	1
Acifluorfen	1.2	38	2
Acifluorfen	1.8	50	3
Acifluorfen	2.4	13	1

[a] Percentage is based on the number of replications in which regrowth had initiated at the axillary buds of treated plants compared to replications in which plants were completely killed among two experiments.

[b] The node fartherest from the base of the plant in which regrowth was observed.

[c] Missing values indicate lack of initial kill, therefore, regrowth could not be measured.

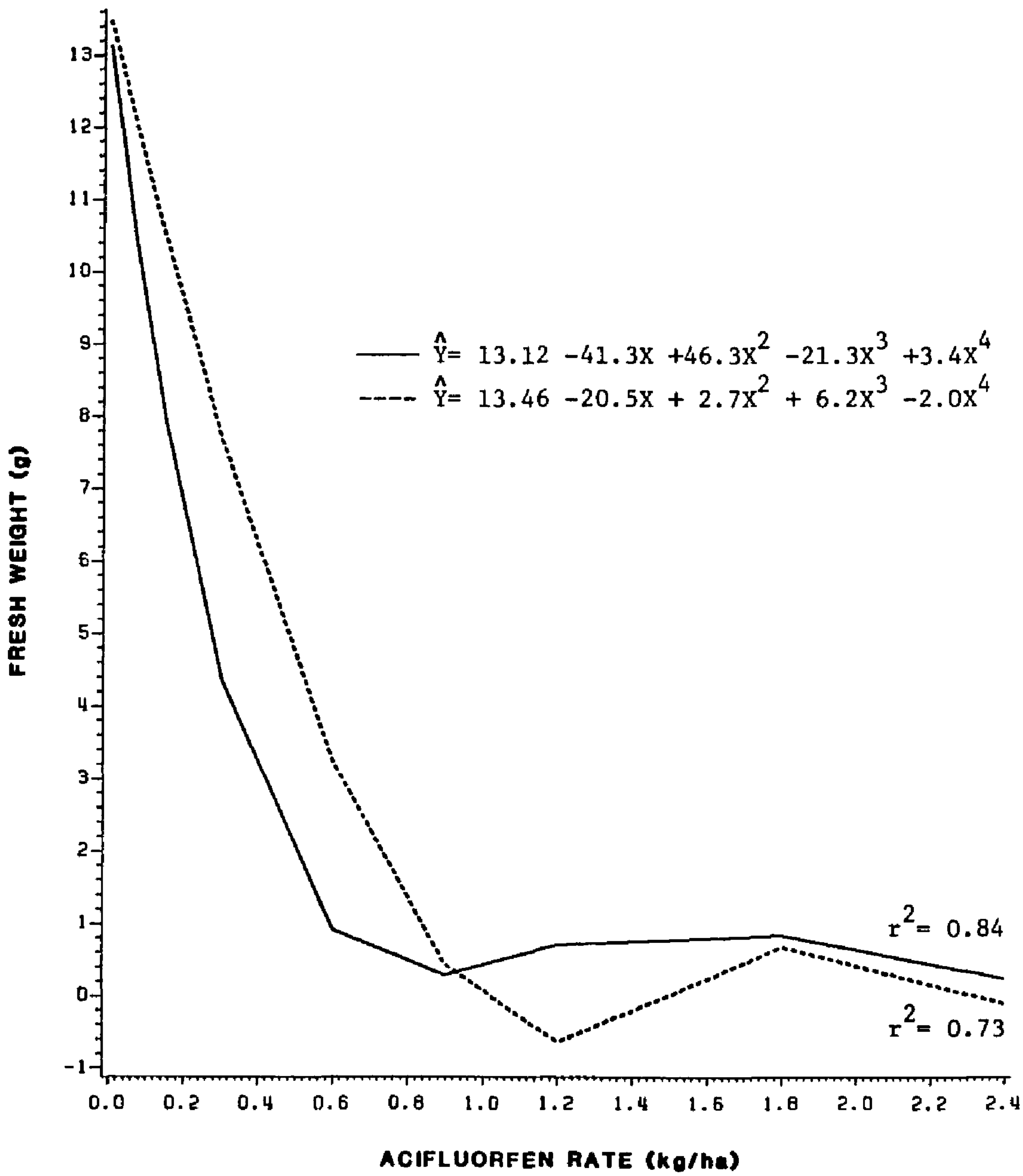

Figure 2. Influence of increasing acifluorfen rate on fresh weight of ivyleaf morningglory in greenhouse studies. Response of experiment 1 (———), Response of experiment 2 (-----).

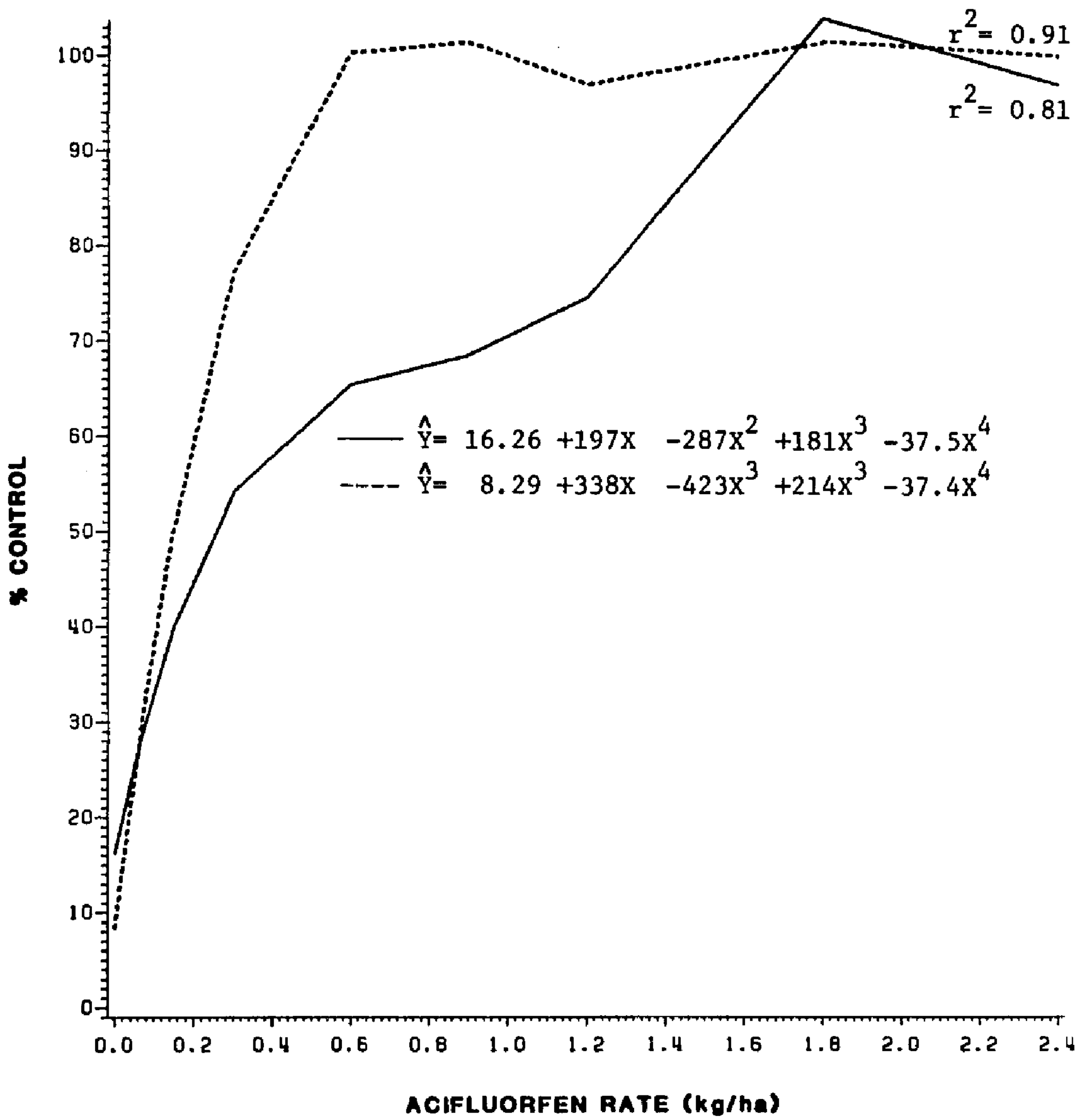

Figure 3. Influence of increasing acifluorfen rate on control of ivyleaf morningglory in field studies. Response of experiment 1 (——) Response of experiment 2 (----).

Under the adverse conditions of experiment 1, only a slight increase in control resulted as the acifluorfen rate was increased from 0.3 to 1.2 kg/ha compared to the rate of increase in control between 0.07 and 0.3 kg/ha. The slope of the best fit line through these portions of the curve are 132 and 38 for the low and high range of rates, respectively. Morningglory control did not reach 100% until the 1.8 kg/ha rate of acifluorfen was applied. The fresh weight measured in the field trials illustrates the greater effectiveness of the acifluorfen on morningglory observed in experiment 2 (Figure 4). In the combined analysis the response of morngglory fresh weight to acifluorfen applications required an additional cubic term to the equation to fit the curvilinear response. These results indicate that under drought stressed conditions, greater control of ivyleaf morngglory is obtained per increment increase of acifluorfen up to 0.3 kg/ha than at rates between 0.3 and 1.2 kg/ha; thus repeated low rate applications of acifluorfen may provide more effective control than increasing the rate of a single application. Under similar conditions Crowder and Harger[3] have demonstrated that two repeated applications of 0.2 kg/ha acifluorfen resulted in as effective control as a single application of 0.6 kg/ha.

Translocation Studies. Within 24 hours after application of the ^{14}C-acifluorfen, treated tissue appeared darkened and initial necrosis was observed. At 72 hours severe necrosis and dessication of treated leaves had occurred. High rates of ^{14}C-acifluorfen caused abscission. Approximately 95 to 98% of the applied ^{14}C-acifluorfen was recovered from the treated leaves. In all the translocation studies, an average of greater than 90% of the ^{14}C-acifluorfen was recovered. The primary concern was the amount of ^{14}C-acifluorfen localized in the nodes of the

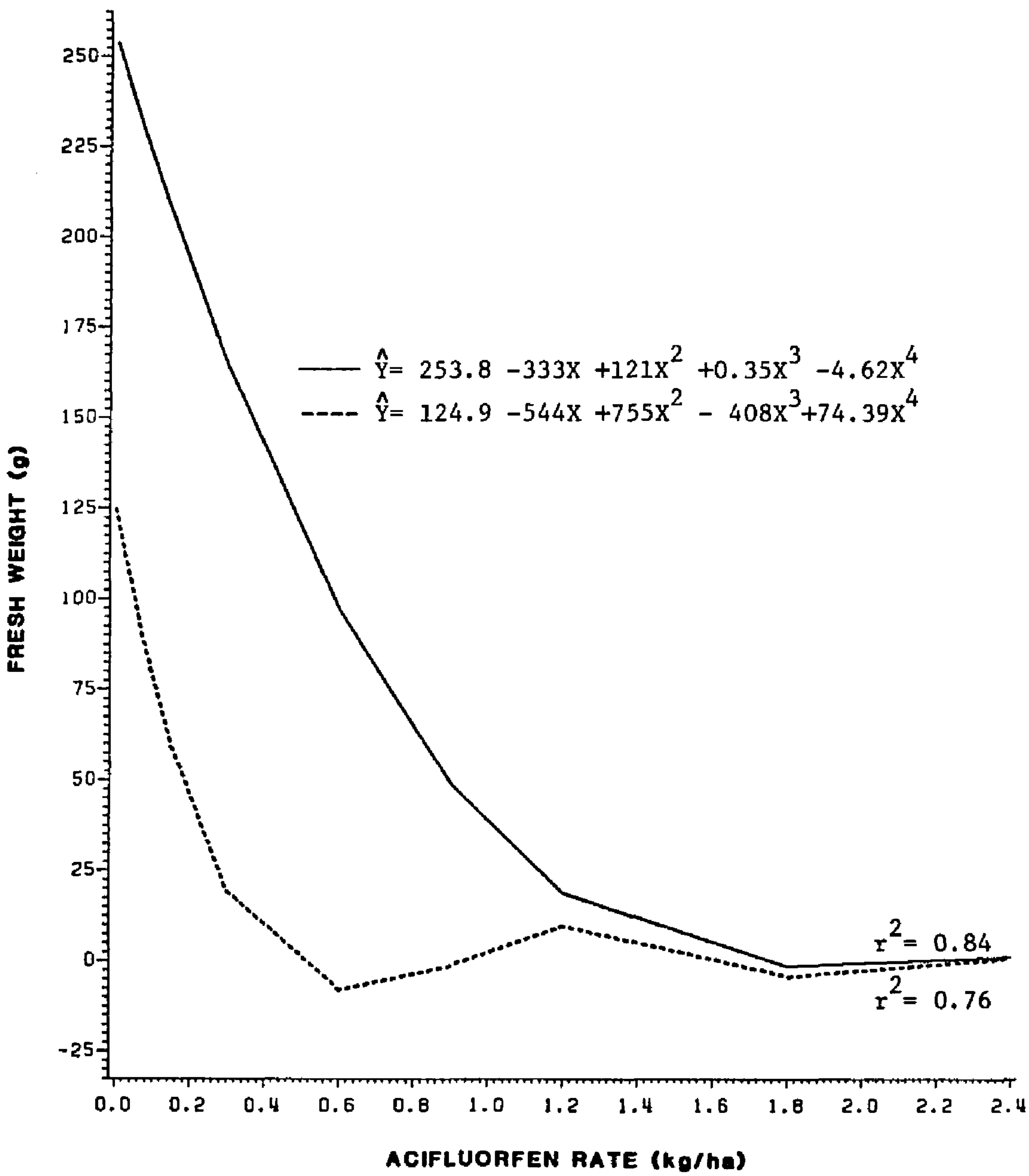

Figure 4. Influence of increasing acifluorfen rate on fresh weight of ivyleaf morningglory in field studies. Response of experiment 1 (——), Response of experiment 2 (----)

two treated leaves and the remainder of stem. The quantitative amount of ^{14}C-acifluorfen localized in the nodes of the two treated leaves are presented according to the harvest interval at which the samples were taken (Figure 5). In the initial translocation experiment, the concentration of ^{14}C-acifluorfen in the stem section between the treated leaves increased as the acifluorfen rate increased. There were no differences in amount of ^{14}C-recovered in this plant section between plants harvested 24, 48, and 72 h after application. The lack of significance in recovery of ^{14}C-acifluorfen between harvest intervals was probably due to the variation in individual observations in the 48 and 72 h analysis, as indicated by the low r^2 values for these predicted lines. The maximum amount of acifluorfen translocation into the stem occurred within 24 hours after application. There were greater differences in ^{14}C-recovered between acifluorfen treatments in the 24-hour analysis.

Upon combustion of the remainder of the stem, there was a difference in the amount of ^{14}C recovered between harvest intervals (Figure 6). The interaction of acifluorfen level applied and the harvest interval was significant at the .05 level of probability. This indicated the amount of ^{14}C-acifluorfen recovered from each acifluorfen treatment was dependent on the harvest interval. As in the analysis of the stem section between the treated leaves, the amount of ^{14}C-acifluorfen localization in the remainder of the stem increased linearly as the herbicide dose rate was increased from 0.15 to 0.6 to 1.2 kg/ha.

The second translocation study was conducted under field and greenhouse conditions. In both experiments, the amount of

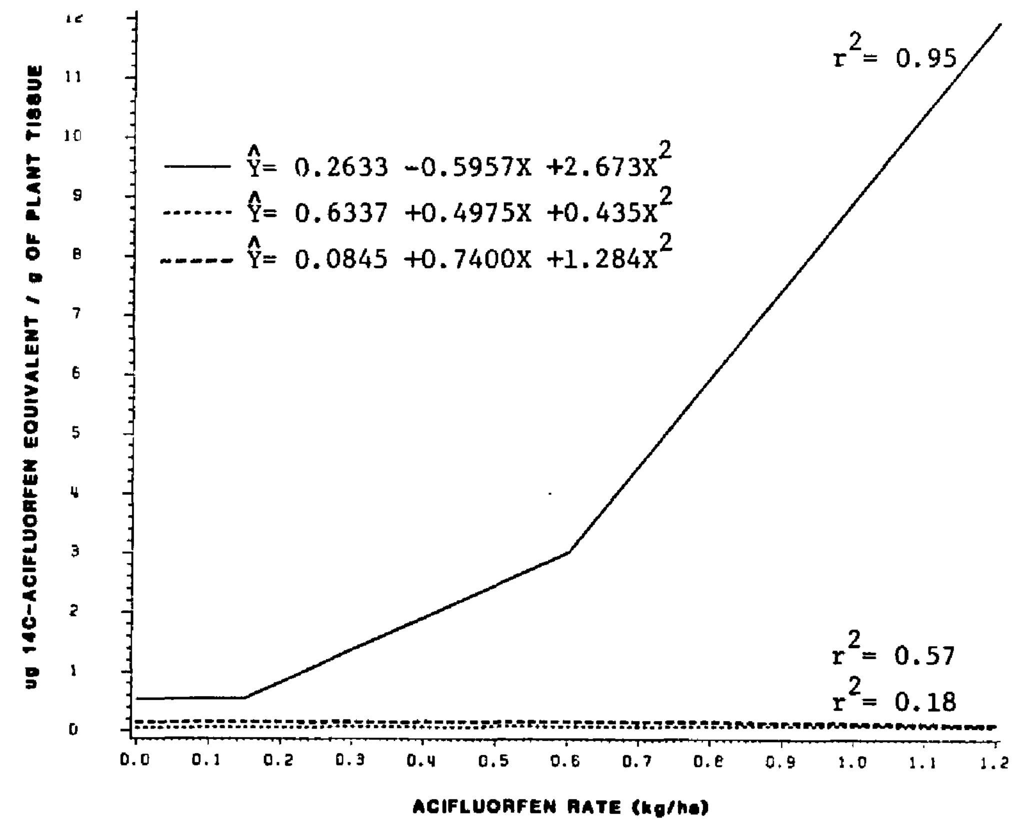

Figure 5. Effect of acifluorfen rate and harvest interval on the amount of ^{14}C recovered from the stem section between the treated leaves of ivyleaf morningglory. Harvest intervals were: 24(——), 48(----), and 72(---) hours.

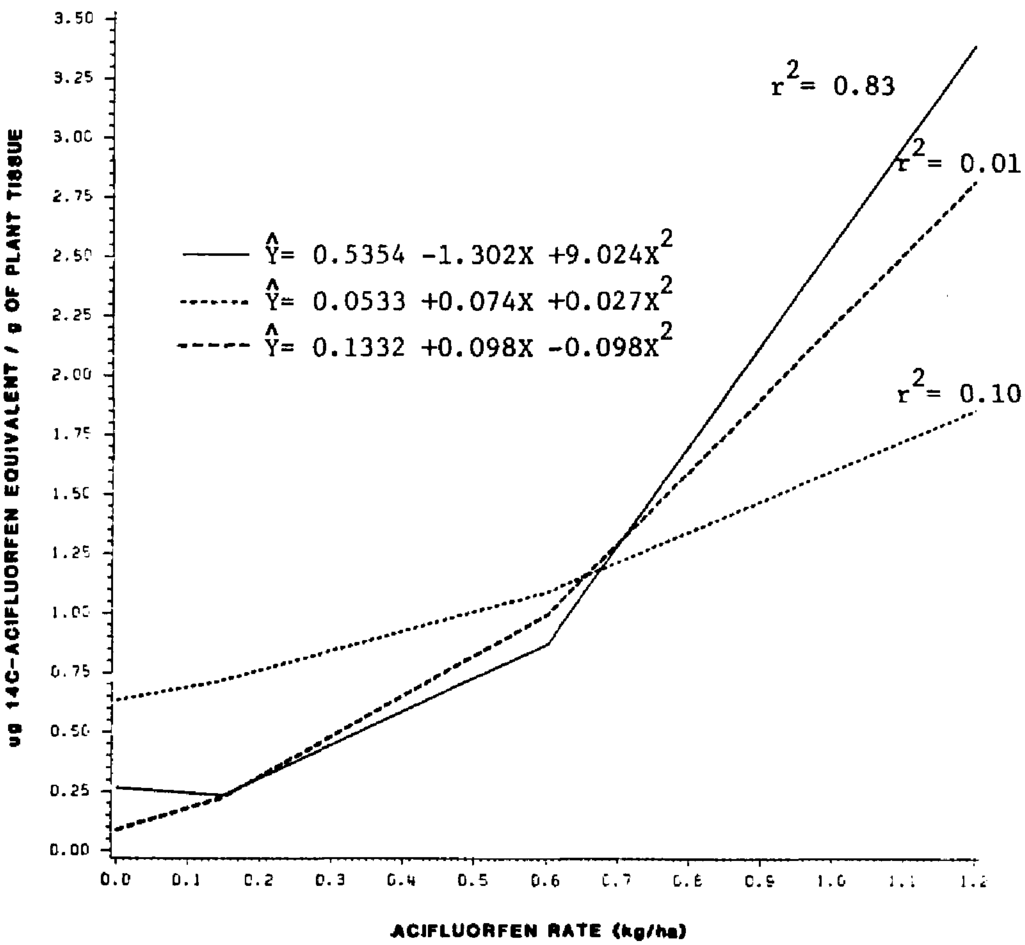

Figure 6. Effect of acifluorfen rate and harvest interval on the amount of ^{14}C recovered from the stem section below the treated leaves of ivyleaf morningglory. Harvest intervals were: 24(——), 48(----), and 72(---) hours.

^{14}C-acifluorfen recovered in both the stem section between and below the treated leaves increased linearly as field acifluorfen rates increased (Figure 7 and 8). A quadratic or cubic term in the equation did not account for a significantly greater portion of the residual variation.

With the addition of the research data from the translocation studies to the greenhouse and field herbicide rate studies, rate of acifluorfen applied to the leaf surface may not be a critical factor in localization of acifluorfen in the nodes. A linear increase in acifluorfen movement to the stem of ivyleaf occurs as the herbicide rate is increased. Since the amount of ^{14}C localized in the nodes decreased considerably after 48 hours (Figure 5), acifluorfen may have either been translocated from the nodes and stem to other plant parts, excreted through the roots, or metabolized to $^{14}CO_2$.

In the second translocation study, large amounts of ^{14}C-aciflurofen accumulated in the stem section between the treated leaves compared to the stem section below the treated nodes (Figure 7 and 8). This may indicate that the concentration in the lower stem section, necessary to prevent regrowth at the axillary buds, could only be achieved via improved spray solution coverage. Control fluctuated just below 100% over a wide range of acifluorfen rates in the rate response experiments (Figure 1 and 3); thus resprouting at the nodes on ivyleaf morningglory was not inhibited by acifluorfen applications.

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The authors gratefully acknowledge the partial financial support by the Louisiana Soybean Promotion Board and the Rohm and Haas Company. They also wish to thank D. F. Goyer and N. E. Seger for their technical assistance and special thanks to Debbie Fuller for her statistical help.

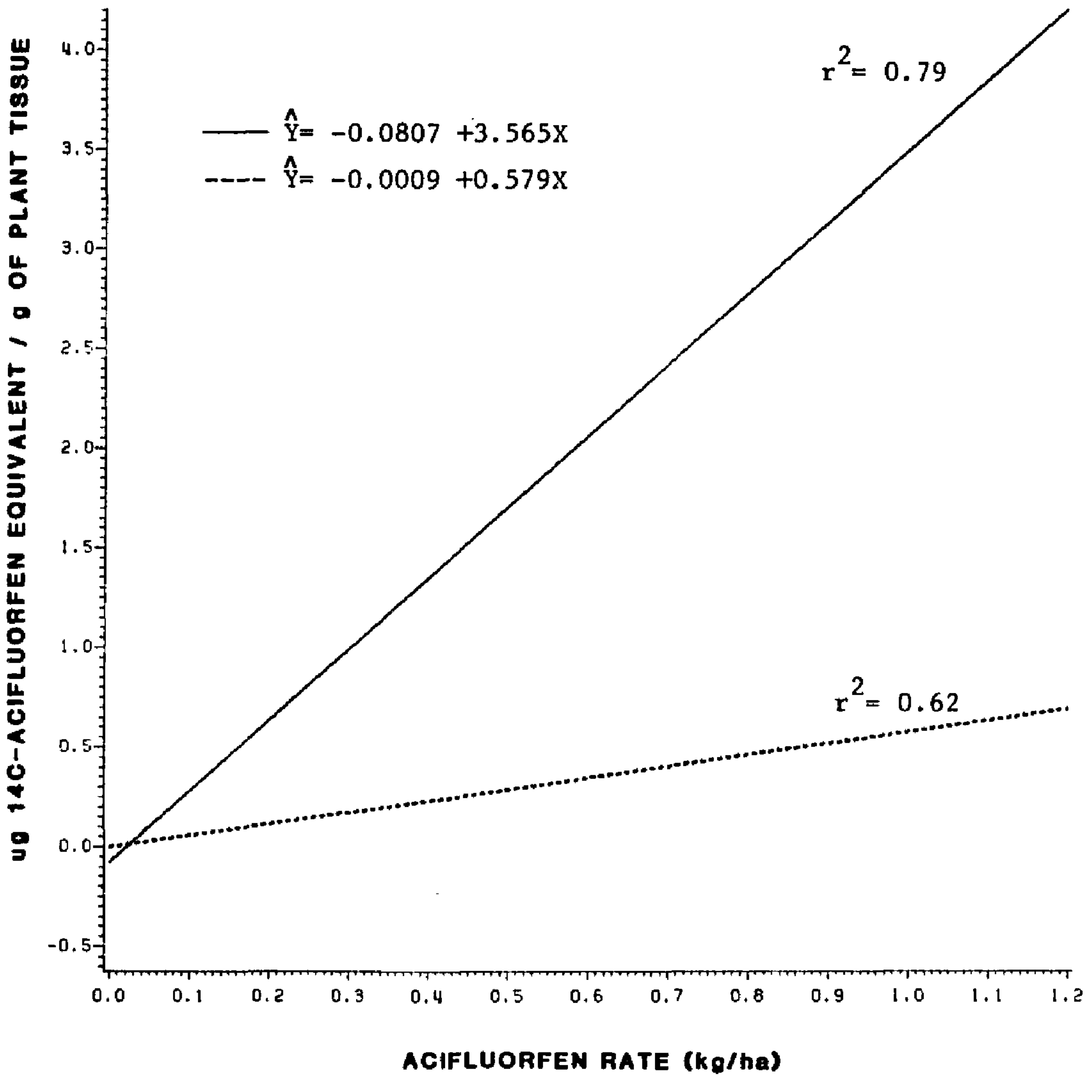

Figure 7. Influence of acifluorfen rate on the amount of ^{14}C recovered from the stem between the treated leaves (———) and the stem below the treated leaves (----) in greenhouse translocation studies.

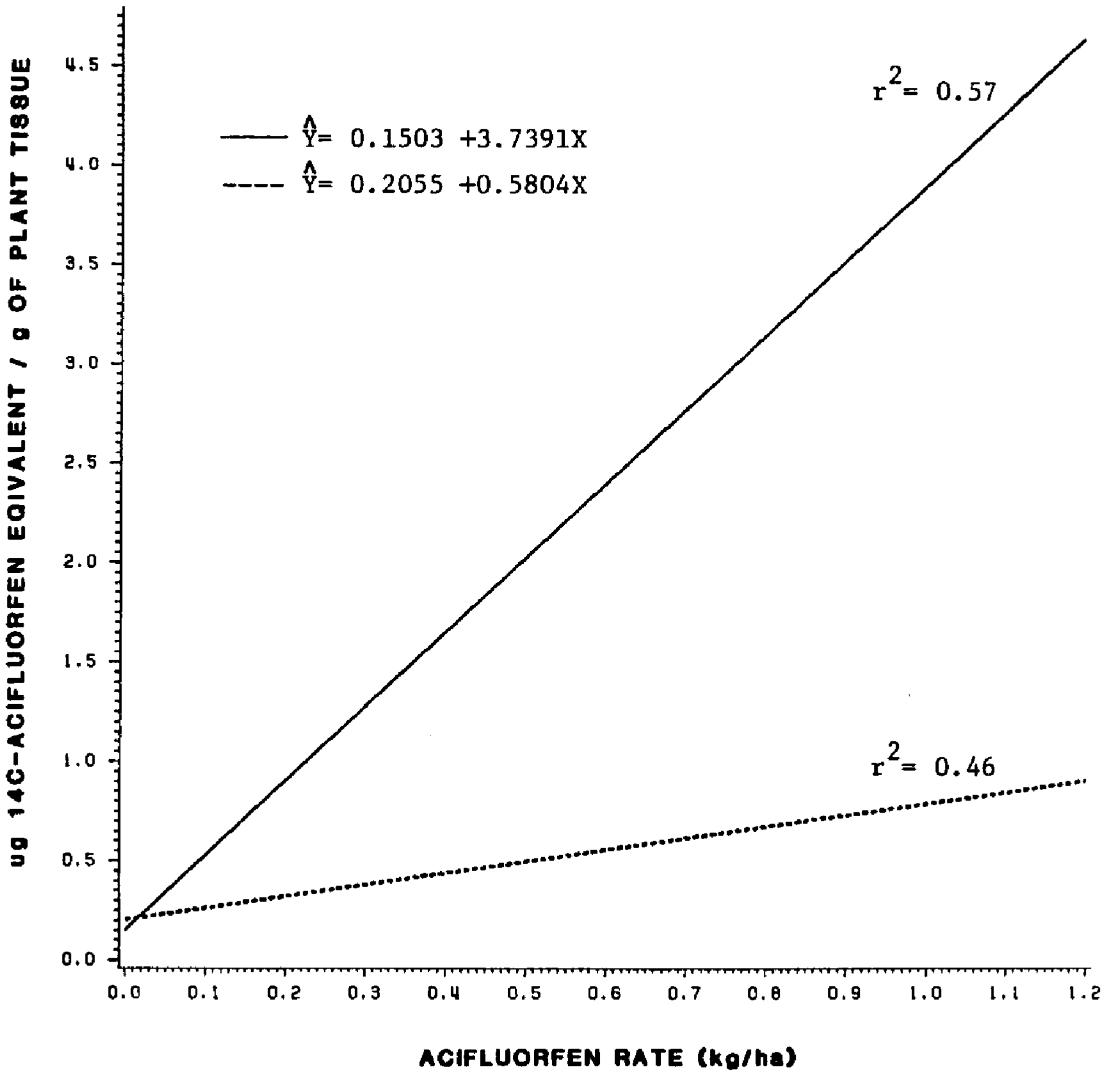

Figure 8. Influence of acifluorfen rate on the amount of ^{14}C recovered from the stem section below the treated leaves (———) and the stem below the treated leaves (----) in field translocation studies.

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MANUSCRIPT III

THE INFLUENCE OF MEFLUIDIDE ON ACIFLUORFEN EFFICACY FOR CONTROL OF MORNINGGLORY AND COCKLEBUR[1]

S. H. CROWDER AND T. R. HARGER[2]

ABSTRACT. In 1981 and 1982, field studies were conducted to determine the influence of mefluidide [N-[2,4-dimethyl-5-[[(trifluoromethyl)-sulfonyl]amino]phenyl]acetamide] applied in combination with acifluorfen [5-[2-chloro-4-trifluoromethyl)phenoxy]-2-nitrobenzoic acid] for weed control in soybeans [*Glycine max* (L.) Merr.]. Acifluorfen at rates of 0.15, 0.3, and 0.6 kg/ha active ingredient were applied as tank-mix or sequential applications (acifluorfen applied 5 days after mefluidide) with 0.15 and 0.3 kg/ha active ingredient of mefluidide. All combinations with mefluidide had improved pitted morningglory (*lpomea lacunosa* (L.)] and common cocklebur (*Xanthium pennsylvanicum* Wallr.) control by the second week after application compared to acifluorfen applied alone. The sequential applications provided higher percent control of both weeds compared to the tank-mix combinations. The addition of mefluidide to acifluorfen improved cocklebur control to a greater degree than morningglory control. Mefluidide-acifluorfen combinations provided superior cocklebur control compared to acifluorfen applied alone either in the V4 or V5 stage of soybean development. In a comparison of tank-mixed bentazon

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[1] Received for publication . These data are from the Ph.D. dissertation of the first author.

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[3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one,2,2-dioxide] and mefluidide, repeated applications of one half rates were more effective than single applications of these herbicides.

Additional index words. Ipomea lacunosa, Xanthium pennsylvanicum, Glycine max, sequential applications, herbicide interaction, tank-mix.

INTRODUCTION

Two of the most troublesome broadleaf weeds found in Southern soybean fields are common cocklebur and morningglory (Ipomea spp.). Effective, yet expensive, postemergence herbicides are presently available for control of specific broadleaf weeds. With increasing herbicide cost, development of improved morningglory and cocklebur control programs utilizing tank-mix and sequential herbicide applications might benefit the soybean producer.

Early season control of morningglory in soybeans can be achieved by preemergence treatments. However, the level of control is dependent on the dominant species and rainfall (13). For maximum postemergence control of morningglory, application should be made in the early stage of morningglory development. The density of foliage growth in later stages causes difficulty in achieving complete coverage with herbicide sprays. Ivyleaf [Ipomea hederacea (L.) Jacq. var: hederacea] and pitted morningglory have been reported as having higher biomass than other morningglory species grown under the same conditions (1). Season-long competition with soybeans may reduce yield as much as 70% (15,21).

Several overtop herbicides are presently available for control of morningglory species. Mathis and Oliver (12) reported that bentazon gave satisfactory control of most morningglory species with the exception of ivyleaf morningglory. Acifluorfen selectively controls many broadleaf weeds when applied as an overtop spray to soybeans (4,10,13,16,17). Mangeot et al. (10) reported optimal soybean yields when acifluorfen was applied at 0.56 kg/ha postemergence during V1 to V4 (2) development stages. In general, most morningglory species are susceptible to applications of acifluorfen (12,13,22), however, some tolerance is exhibited by ivyleaf morningglory (13). Hartnett (8) and Mathis (11) achieved excellent control of ivyleaf morningglory using rates between 0.3 and 0.56 kg/ha of acifluorfen applied to plants with less than 8 nodes. Rogers and Crawford (19) indicated that rates of 0.28 to 0.56 kg/ha of acifluorfen were required to give 90 to 100% control of ivyleaf and pitted morningglory less than 20 cm long, while rates of 0.84 to 1.12 kg/ha were required to give comparable control of morningglories 20 to 38 cm long.

Cocklebur often causes soybean yield reductions of 50 to 80% (4). In evaluation of postemergence herbicides, Overton et al. (16) emphasized the need for early control of cocklebur in soybeans. With increased annual grass control using preemergence herbicides in soybeans, release of tolerant broadleaf weeds has created a new problem (3). Under these circumstances, cocklebur and morningglory cause problems to the Southern soybean farmer. Control of common cocklebur less than 15 cm in height has been achieved with applications of acifluorfen ranging from 0.4 kg/ha to 0.9 kg/ha (4,10,11,16,19). However, in more advanced stages of growth, rates of acifluorfen between 0.9 kg/ha and 1.12 kg/ha are necessary for effective cocklebur control (16). Repeated applications of acifluorfen between 0.2 kg/ha and 0.42 kg/ha applied to 15 to 25 cm cocklebur are sometimes necessary for satisfactory results (16).

Mefluidide has been reported to control several troublesome weeds in soybeans (6,14,18,20). Rogers and Crawford (18) averaged 40 and 80% control of morningglory and cocklebur, respectively, using mefluidide at rates of 0.3 to 0.6 kg/ha. McWhorter and Barrentine (14) achieved 92% control of cocklebur with 0.56 kg/ha of mefluidide with 0.5% (v/v) nonoxynol [α-(p-nonyl-phenyl)-w-hydroxypoly (oxyethylene)] surfactant in a directed spray.

Additional weeds and/or larger weeds in soybeans have been controlled when mefluidide was used in combination with other herbicides. Hargroder et al. (6) improved control of morningglory and cocklebur when mefluidide was used in combination with bentazon. Rogers et al. (20) increased efficacy of bentazon in controlling larger weeds and weeds that were not readily controlled with lower rates, using mefluidide in combination.

In order to increase the effective use of acifluorfen for broadleaf weed control in soybeans, tank-mix and sequential applications of acifluorfen with other herbicides have been investigated (5,7,9). Harrison et al. (7) conducted studies to define the efficacy and crop tolerance of acifluorfen and 2,4-DB [4-(2,4-dichlorophenoxy) butanoic acid] combinations to increase the size limits of weeds, particularly common cocklebur and ivyleaf morningglory, controlled by acifluorfen. Acifluorfen at 0.56 kg/ha tank mixed with 0.034 kg/ha 2,4-DB resulted in acceptable control of 4 to 8 leaf common cocklebur and ivyleaf morningglory with acceptable crop tolerance. Kelley et al. (9), found that the addition of bentazon at 0.56 kg/ha to acifluorfen at 0.42 to 0.56 kg/ha consistently provided superior control of mixed weed populations. In field studies involving mefluidide with sequential applications of acifluorfen, Hargroder et al. (5) found that mefluidide applied at 0.21 kg/ha followed 1 to 5 days later with 0.42 kg/ha acifluorfen, provided consistent control of several weed species, including common cocklebur. Sequential applications of mefluidide and acifluorfen allows the use of the two postemergence herbicides for their label purposes while offering more economical and effective weed control (5). The objective of this research was to evaluate tank-mix and sequential applications of mefluidide and acifluorfen for control of morningglory and cocklebur under field conditions.

MATERIALS AND METHODS

The study was conducted at the Burden Research Plantation at Baton Rouge, Louisiana on an Olivier silt loam soil containing less than 1% organic matter and a pH of 7.2. The test area received 280 and 140 kg/ha of 0-24-24 fertilizer in 1981 and 1982, respectively. Prior to the 1981 season, 2200 kg/ha of lime was applied over the test area to increase the pH from 6.3 to 7.2. The test area was overseeded with locally collected seed to increase the population of common cocklebur and pitted morningglory. Conventional cultural practices, including double-discing and smoothing with a field cultivator, were utilized in seedbed preparation. 'Davis' and 'Forrest' soybeans were planted on May 21, 1981 and on May 10, 1982, respectively, on 82 cm rows at a seeding rate of 40 seeds per meter. After planting in both years, an application of 0.9 kg/ha of oryzalin (3,5-dinitro-$\underline{N}^4$,$\underline{N}^4$- = dipropylsulfanilamide) was applied over the test area. The average weed densities were 6 cocklebur/m^2 and 30 pitted morningglory/m^2.

The experiment was established as a randomized complete block design with four replications. The treated area measured 5 by 2 meters including two rows of soybeans. Each treated area was bounded on either side by two untreated rows.

Approximately three weeks after planting in 1981 and 1982, herbicide treatments (Tables 2 and 3) were applied with a hand-held CO_2 pressurized broadcast boom, with five 8003[3] nozzles delivering 200 L/ha of spray solution. Various combinations of tank-mix and sequential applications of mefluidide with bentazon and acifluorfen were applied on two application dates. The second application of herbicides was applied five days after the initial treatments. All herbicide applications, except those containing acifluorfen, contained a non-ionic surfactant[4] at 0.25% (v/v) in the spray solution.

The soybeans were in the V4 (2) stage of development at the first application date and V5 stage at the second application of the overtop herbicides. In 1981, both the morningglory and cocklebur plants had two to four true leaves at the first herbicide application. In 1982, morningglory plants had four to eight true leaves and the cocklebur plants had five to seven true leaves at the first herbicide application. In 1981, 46 cm of rain was recorded during the growing season from May through August compared to 32 cm in 1982. Rainfall amounts recorded 12 days before and after initial herbicide treatments are presented in Table 1.

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[3] Nozzles used in these studies are a product of Spraying Systems Company.

[4] Ortho X-77

Table 1. Rainfall data 12 days before and after initial postemergence applications of acifluorfen in 1981 and 1982.

Planting Date	Days before application 12-10	9-7	6-4	3-1	Application Date	Days after application 0-3	4-6	7-9	10-12
	cm					cm			
5-21-81	0.64	4.70	4.01	0.64	6-14-81	0	0	1.98	3.43
5-10-82	0.89	0	0	0	5-31-82	0.64	0	0	0

Weed control was visually estimated at approximately 10 and 18 days after the initial herbicide application in 1981 and 1982. After the second rating, the treated rows were cultivated with a rolling cultivator, and the adjacent untreated rows were mowed to prevent morningglory vines from spreading to the treated areas and interfering with harvest. All percent control and soybean injury data were based on visual comparisons with adjacent untreated rows or weedy control plots. Soybean yields were obtained by harvesting both treated rows with a small plot combine. Visual ratings and yield data were subjected to standard analysis of variance and the F-test was used to test comparisons between selected treatments as indicated in Tables 2 and 3.

RESULTS AND DISCUSSION

In general, morningglory and cocklebur control increased as the rate of acifluorfen was increased from 0.15 to 0.3 to 0.6 kg/ha (Table 2). However, decreases in morningglory control were observed at the initial (ED1) and harvest (ED3) evaluations when the acifluorfen rate was increased from 0.15 to 0.3 kg/ha at the second application date. Applying acifluorfen either on the first or second application date did not affect performance in controlling morningglory or cocklebur (Table 2).

Several sets of treatments were compared statistically to determine the effectiveness of combining mefluidide with acifluorfen either as tank-mix or sequential applications (Table 2). There was no difference in morningglory control between any of the comparisons at the first evaluation (ED1). In tank mix combinations there was no differences between mefluidide rates used. However, there was a significant reduction in morningglory control at the harvest rating (ED3) when

Table 2. The influence of acifluorfen applied alone and in combination with mefluidide on percent control of morningglory and cocklebur in soybeans.

Herbicide Timings: 1st Application (V4)	Rate		Treatment[b]	Rate	2nd Application (V5)	Rate	Weed Control[a] Morningglory ED1	Morningglory ED2	Morningglory ED3	Cocklebur ED1	Cocklebur ED2	Soybean Yield (kg/ha)
							-----	-----	%	-----	-----	
Mefluidide	0.15	+	Acifluorfen	0.15			61	64	65	74	70	2455
"	0.15	+	"	0.3			93	93	75	89	87	2478
"	0.15	+	"	0.6			95	87	72	93	93	2388
Mefluidide	0.3	+	Acifluorfen	0.15			68	77	58	78	79	2267
"	0.3	+	"	0.3			92	90	71	84	83	2475
"	0.3	+	"	0.6			95	93	77	94	93	2266
Mefluidide	0.15				Acifluorfen	0.15	86	82	74	80	85	2300
"	0.15				"	0.3	93	93	84	88	89	2379
"	0.15				"	0.6	98	98	84	97	97	2600
Mefluidide	0.3				Acifluorfen	0.15	87	89	57	84	87	2325
"	0.3				"	0.3	93	97	72	93	94	2697
"	0.3				"	0.6	98	100	79	97	97	2541
Acifluorfen	0.15						67	72	75	72	62	2000
"	0.3						92	86	77	82	77	2465
"	0.6						98	93	78	95	89	2517
					Acifluorfen	0.15	79	69	75	63	48	2224
					"	0.3	73	89	68	69	69	2330
					"	0.6	96	97	75	93	94	2765
Control -							0	0	0	0	0	1360

[a] Percent control at the indicated time after V4 application. ED1 = 10 days, ED2 = 18 days, ED3 = Harvest.
[b] Rates are kg/ha active ingredient.

Table 2. (continued)

Treatment Comparisons	Weed Control Morningglory ED1[a]	ED2	ED3	Cocklebur ED1	ED2	Soybean Yield
Mefluidide +[b] acifluorfen vs. mefluidide seq.[c] acifluorfen		*[d]			*	
Mefluidide 0.15 + acifluorfen vs. mefluidide 0.3 + acifluorfen						
Mefluidide 0.15 seq. acifluorfen vs. mefluidide 0.3 seq. acifluorfen			*			
Mefluidide + acifluorfen vs. acifluorfen V4						
Mefluidide seq. acifluorfen vs. acifluorfen V5				**	**	
Mefluidide seq. acifluorfen vs. acifluorfen V4		**			**	
Combinations of mefluidide and acifluorfen vs. acifluorfen V4		*			**	
Combinations of mefluidide and acifluorfen vs. acifluorfen V5				**	**	
Acifluorfen V4 vs. acifluorfen V5						

[a] ED - Evaluation dates after application.

[b] + - tank-mixture of acifluorfen and mefluidide.

[c] seq. - Sequential applications of acifluorfen 5 days after mefluidide pretreatment.

[d] * - Significant at the .05 level of probability as determined by F-test.
** - Significant at the .01 level of probability as determined by F-test.

the mefluidide rate, in sequential combinations was increased from 0.15 kg/ha to 0.3 kg/ha.

The sequential applications of acifluorfen were more effective for both morningglory and cocklebur control at the second evaluation date (ED2) compared to the tank-mix combinations. The tank-mix combination and acifluorfen applied alone at the V4 stage were not different in control of either weed at any evaluation date. Although all treatments with mefluidide combined with acifluorfen, by either method, had improved control of both weeds by the second evaluation date, the sequential applications of acifluorfen were highly significant (probability of $a>F<.01$) in improving control compared to acifluorfen alone applied at V4.

Addition of mefluidide to the acifluorfen program improved cocklebur control to a greater extent than morningglory control (Table 2). Combinations of mefluidide and acifluorfen provided better control of cocklebur at both evaluation dates compared to acifluorfen applied alone at V5. Sequential applications were superior to all other treatments in control of cocklebur.

Soil moisture conditions in 1981 were more favorable for plant growth (Table 1). Under these conditions, the sequential applications of acifluorfen following mefluidide averaged 92% control of cocklebur over all rates, whereas, acifluorfen applied alone averaged 80% control. In drier conditions in 1982, the mefluidide pretreatment increased control to 91% compared to an average of 66% by acifluorfen alone. Therefore, the pretreatment had a greater effect on acifluorfen performance under the drier conditions.

When mefluidide was tank-mixed with bentazon, there was no change in control of morningglory or cocklebur compared to bentazon alone (Table 3). At both the first and second evaluation dates of morningglory control, the split application of the tank-mix combination improved control over the single application. Similar results with split applications of acifluorfen in earlier studies resulted in increased control of ivyleaf morningglory.[5]

Yield data were collected both years, but were not affected by treatments containing mefluidide compared to acifluorfen or bentazon applied alone. Initial soybean injury was observed but was not a factor in reducing soybean production.

Under conditions of these experiments mefluidide applied alone was not effective in controlling morningglory or cocklebur (Table 3). However, by these direct comparisons, mefluidide used in combination with acifluorfen as a pretreatment greatly enhances acifluorfen performance in controlling cocklebur and to a lesser extent morningglory.

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[5] Crowder and Harger, unpublished data.

Table 3. The influence of bentazon applied alone and in combination with mefluidide on percent control of morningglory and cocklebur in soybeans.

Herbicide Timings Treatment[b] 1st Application (V4)	2nd Application (V5)	Weed Control[a] Morningglory ED1 (%)	Morningglory ED2 (%)	Morningglory ED3 (%)	Cocklebur ED1 (%)	Cocklebur ED2 (%)	Yield (kg/ha)
Mefluidide 0.15		8	18	21	18	49	1506
Mefluidide 0.3		4	23	21	14	37	1446
Mefluidide 0.15 + Bentazon 0.6		83	68	46	97	93	1911
Mefluidide 0.15 + Bentazon 0.9		78	80	58	93	88	2001
Mefluidide 0.07 + Bentazon 0.3	Mefluidide 0.07 + Bentazon 0.3	94	84	55	95	93	2282
Mefluidide 0.07 + Bentazon 0.45	Mefluidide 0.07 + Bentazon 0.45	95	92	71	100	96	2665
Bentazon 0.6		68	49	32	85	94	2409
Bentazon 0.9		84	80	66	96	91	2075
Control -		0	0	0	0	0	1360

Treatment Comparisons	Morningglory ED1	Morningglory ED2	Morningglory ED3	Cocklebur ED1	Cocklebur ED2	Yield
Single application mefluidide tank-mix bentazon vs. split applications	*[c]	*				
Mefluidide tank-mix bentazon vs. bentazon alone V4						

[a] Percent control at the indicated time after V4 application. ED1 = 10 days, ED2 - 18 days, ED3 = Harvest.

[b] Rates are kg/ha active ingredient.

[c] * - Significant at the 0.5 level of probability as determined by F-test.

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SUMMARY

In both the 1981 and 1982 field studies, repeated low rate applications of 0.2 kg/ha acifluorfen were significant in improving control of ivyleaf morningglory without injury to the soybeans. Two applications of 0.2 kg/ha acifluorfen in 1981 provided a significant increase in control over the single application of 0.6 kg/ha. In 1982, this treatment resulted in similar control using one third less herbicide.

Repeated low rate acifluorfen applications were also tested on pitted morningglory and common cocklebur. Initial field studies were conducted according to materials and methods described in Manuscript I and results are presented in Appendix Tables I-1 and I-3. Results of a preliminary greenhouse study on cocklebur are also presented in Appendix Table I-2. Based on these initial results, the repeated low rate applications did not increase the acifluorfen efficacy compared to a single application of the recommended rate.

In the acifluorfen rate studies, maximum control of ivyleaf morningglory under greenhouse conditions was achieved at rates of 0.6 to 0.9 kg/ha. Deviation from 100% control at higher rates was due to recovery of the treated plants by regrowth at the axillary buds of the lower nodes rather than a lack of phytotoxicity to actual treated tissue.

Translocation of ^{14}C-acifluorfen into the treated leaf node and lower stem increased linearly as herbicide rate applied to the leaves increased. However, in time studies with ^{14}C-acifluorfen translocation, significant differences occurred in the amount of ^{14}C recovered between sampling intervals of 24, 48, and 72 hours. Analysis of covariance results of the acifluorfen rate study and ^{14}C translocation studies are presented in Appendix Tables II-1 through II-8. The micrograms of ^{14}C-acifluorfen recovered from each plant section are presented in Appendix Tables II-9 through II-13. Greater than 90% of the ^{14}C-acifluorfen recovered in combustion analysis came from the treated leaves.

Acifluorfen rate studies were also conducted on a limited basis with pitted morningglory and common cocklebur (Appendix Tables II-14 through II-17) in both greenhouse and field experiments. Deviations from a continuous increase in percent control as acifluorfen rate increased was due to a lack of initial phytotoxicity while regrowth of treated plants was minimal. Translocation of ^{14}C-acifluorfen into the stem of pitted morningglory and common cocklebur was measured at 24 and 48 hours after application (Tables II-18 through II-21). Larger amounts of ^{14}C-acifluorfen equivalent were translocated to the upper and lower stem in pitted morningglory and cocklebur compared to ivyleaf morningglory. All materials and methods used in these initial studies are identical to those described in Manuscript II.

Based on field studies from 1981 and 1982, acifluorfen applied in combination with mefluidide improved control of pitted morningglory and cocklebur compared to acifluorfen applied alone at the V4 stage of soybean development. The sequential applications of acifluorfen applied 5 days after pretreatment with mefluidide were significantly higher in percent control of both weeds compared to the tank-mix combinations.

Analysis of variance tables from which the direct comparisons were made are presented in Appendix Tables III-1 through III-6.

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APPENDIX I

Appendix Table I-1. Influence of repeated applications of acifluorfen at 0.2 kg/ha compared to single applications on percent control and fresh weight of pitted morningglory in field experiments.

Treatment[a]	Rate	Applications	Weed control[b]		Fresh weight
	(kg/ha)	(no.)	-----(%)----		(g)
Acifluorfen	0.6	1	98a[c]	98a	0 b
"	0.4	1	88ab	83b	0.63b
"	0.2	1	83b	63c	2.15b
"	0.2	2	93ab	93ab	0.08b
"	0.2	3	95ab	100a	0 b
Control	-	-	0c	0d	21.06a

[a] Initial treatments were applied three weeks after planting on 5-31-82 with sequential applications following at three-day intervals.

[b] Weed control evaluations were made on 6-10-82 and 6-23-82, respectively, with fresh weight measured after the last visual rating.

[c] Means within a column followed by the same letter are not significantly different at alpha = .05 by Duncan's multiple range test.

Appendix Table I-2. Influence of repeated applications of acifluorfen at 0.2 kg/ha compared to single applications on percent control and fresh weight of common cocklebur in greenhouse experiments.

Treatment	Rate	Applications[a]	Weed control[b]	Fresh weight
	(kg/ha)	(no.)	(%)	(g)
Acifluorfen	0.6	1	83a[c]	3d
"	0.4	1	23d	14b
"	0.2	1	57bc	11c
"	0.2	2	50c	13b
"	0.2	3	60b	10c
Control	-	-	0e	18a

[a] Sequential applications were made at three-day intervals.

[b] Evaluations were made 21 days after initial applications.

[c] Means within a column followed by the same letter are not significantly different at alpha = .05 by Duncan's multiple range test.

Appendix Table I-3. Influence of repeated applications of acifluorfen at 0.2 kg/ha compared to single applications on percent control and fresh weight of common cocklebur in field experiments.

Treatment[a]	Rate	Applications	Weed control[b]		Fresh weight
	(kg/ha)	(no.)	----(%)-----		(g)
Acifluorfen	0.6	1	93a[c]	85ab	3.7b
"	0.4	1	83a	73b	6.3b
"	0.2	1	78a	55c	4.6b
"	0.2	2	90a	80ab	5.6b
"	0.2	3	85a	93a	1.2b
Control	-	-	0b	0d	47.4a

[a] Initial treatments were applied three weeks after planting on 5-31-82 with sequential applications following at three-day intervals.

[b] Weed control evaluations were made on 6-10-82 and 6-23-82, respectively, with fresh weight measured after the last visual rating.

[c] Means within a column followed by the same letter are not significantly different at alpha = .05 by Duncan's multiple range test.

APPENDIX II

Appendix Table II-1. Analysis of covariance.

Dependent variable: Ivyleaf morningglory percent control - Greenhouse Experiments $r^2 = 0.93$

Source of variation	df	Type I SS	F-Value	Probability > F
Model	9	107832		
Level[a]	(1)	63757	485.26	.0001
$Level^2$	(1)	31450	239.37	.0001
$Level^3$	(1)	9601	73.08	.0001
$Level^4$	(1)	932	7.09	.0099
Experiment	(1)	672	5.12	.0272
Level x Experiment[b]	(1)	828	6.30	.0147
$Level^2$ x Experiment	(1)	33	0.25	.6166
$Level^3$ x Experiment	(1)	240	1.83	.1812
$Level^4$ x Experiment	(1)	318	2.42	.1251
Error	62	8146		
Corrected total	71	115978		

[a] Level = Acifluorfen treatment

[b] Interaction of Exp. 1 and Exp. 2

Appendix Table II-2. Analysis of covariance.

Dependent variable: Ivyleaf morningglory fresh weight - Greenhouse Experiments $r^2 = 0.77$

Source of variation	df	Type I SS	F-Value	Probability > F
Model	9	1845		
Level[a]	(1)	1153.2	135.25	.0001
Level^2	(1)	519.0	60.87	.0001
Level^3	(1)	116.6	13.68	.0005
Level^4	(1)	1.1	0.13	.7156
Experiment	(1)	15.8	1.85	.1786
Level x Experiment[b]	(1)	16.0	1.87	.1760
Level^{2}x Experiment	(1)	0.7	0.09	.7698
Level^{3}x Experiment	(1)	7.1	0.84	.3639
Level^{4}x Experiment	(1)	15.8	1.86	.1778
Error	62	529		
Corrected total	71	2374		

a Level = Acifluorfen treatment

b Interaction of Exp. 1 and Exp. 2

Appendix Table II-3. Analysis of covariance.

Dependent variable: Ivyleaf morningglory percent control - Field Experiments $r^2 = 0.87$

Source of variation	df	Type I SS	F-Value	Probability > F
Model	9	71490		
Level[a]	(1)	45128	271.41	.0001
Level^2	(1)	13301	80.00	.0001
Level^3	(1)	2904	17.47	.0001
Level^4	(1)	3087	18.57	.0001
Experiment	(1)	3068	18.45	.0001
Level x Experiment[b]	(1)	24	0.14	.7073
Level^2 x Experiment	(1)	2112	12.70	.0007
Level^3 x Experiment	(1)	1866	11.22	.0014
Level^4 x Experiment	(1)	0	0.00	.9948
Error	62	10309		
Corrected total	71	81799		

[a] Level = Acifluorfen treatment

[b] Interaction of Exp. 1 and Exp. 2

Appendix Table II-4. Analysis of covariance.

Dependent variable: Ivyleaf morningglory fresh weight - Field Experiments $r^2 = 0.86$

Source of variation	df	Type I SS	F-Value	Probability > F
Model	9	528243		
Level[a]	(1)	250776	180.20	.0001
$Level^2$	(1)	78637	56.51	.0001
$Level^3$	(1)	10263	7.37	.0086
$Level^4$	(1)	2681	1.93	.1701
Experiment	(1)	118479	85.14	.0001
Level x Experiment[b]	(1)	57385	41.23	.0001
$Level^2$ x Experiment	(1)	4534	3.26	.0759
$Level^3$ x Experiment	(1)	2051	1.47	.2294
$Level^4$ x Experiment	(1)	3438	2.47	.1211
Error	62	86283		
Corrected total	71	614526		

[a] Level = Acifluorfen treatment

[b] Interaction of Exp. 1 and Exp. 2

Appendix Table II-5. Analysis of covariance.

Dependent variable: Micrograms of ^{14}C-acifluorfen equivalent (Stem section between treated leaves) r^2=0.61

Source of variation	df	Type I SS	F-Value	Probability >F
Model	8	37		
Level[a]	(1)	31.13	34.32	.0001
$Level^2$	(1)	1.68	1.86	.1844
Hours[b]	(2)	0.17	0.09	.9132
Level x hours	(2)	3.82	2.11	.1413
$Level^2$ x hours	(2)	0.67	0.37	.6953
Error	27	24		
Corrected total	35	61		

[a] Level = Acifluorfen treatment

[b] Hours = 24, 48, 72 h after application

Appendix Table II-6. Analysis of covariance.

Dependent variable: Micrograms of ^{14}C-acifluorfen equivalent (Stem section below treated leaves) r^2=0.87

Source of variation	df	Type I SS	F-Value	Probability > F
Model	8	387		
Level[a]	(1)	82	39.11	.0001
Level^2	(1)	7	3.31	.0799
Hours[b]	(2)	122	29.23	.0001
Level x hours	(2)	162	38.88	.0001
Level^2 x hours	(2)	14	3.45	.0462
Error	27	56		
Corrected total	35	443		

[a] Level = Acifluorfen treatment

[b] Hours = 24, 48, and 72 h after application

Appendix Table II-7. Analysis of covariance.

Dependent variable: Micrograms of ^{14}C-acifluorfen equivalent (Greenhouse Translocation) $r^2 = 0.84$

Source of variation	df	Type I SS	F-Value	Probability >F
Model	3	62		
Level[a]	(1)	27.54	75.29	.0001
Variable[b]	(1)	19.93	54.28	.0001
Level x variable	(1)	14.30	39.09	.0001
Error	32	12		
Corrected total	35	74		

[a] Level = Acifluorfen treatment

[b] Variable = Stem section below treated leaves
Stem section between treated leaves

Appendix Table II-8. Analysis of covariance.

Dependent variable: Micrograms of ^{14}C-acifluorfen equivalent (Field Translocation) $r^2 = 0.67$

Source of variation	df	Type I SS	F-Value	Probability > F
Model	3	69		
Level[a]	(1)	29.87	27.63	.0001
Variable[b]	(1)	23.08	21.35	.0001
Level x variable	(1)	15.96	14.77	.0005
Error	32	35		
Corrected total	35	104		

[a] Level = Acifluorfen treatment

[b] Variable = Stem section below treated leaves
Stem section between treated leaves

Appendix Table II-9. Micrograms of ^{14}C-acifluorfen equivalent per gram of ivyleaf morningglory tissue recovered 24 hours after application.

Treatment/Rate		Treated[a] leaves	Area above treated leaves	Stem between[b] treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	61.47	0.47	0.44	0.47	0.01	0.02
Acifluorfen	0.6	293.44	0.98	0.78	3.04	0.06	0.03
Acifluorfen	1.2	576.15	3.39	3.42	11.96	0.13	0.15
Control	---	0.02	0.05	0.13	0.01	0.01	0.02

[a] Consisted of two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves

Appendix Table II-10. Micrograms of ^{14}C-acifluorfen equivalent per gram of ivyleaf morningglory tissue recovered 48 hours after application.

Treatment/Rate		Treated[a] leaves	Area above treated leaves	Stem between[b] treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	66.81	0.56	1.61	0.13	0.54	0.03
Acifluorfen	0.6	271.80	0.72	0.70	0.06	1.74	0.05
Acifluorfen	1.2	590.24	1.30	1.94	0.11	0.25	0.19
Control	---	.02	0.01	0.05	0.01	0.01	0.01

[a] Consisted of two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves

Appendix Table II-11. Micrograms of ^{14}C-acifluorfen equivalent per gram of ivyleaf morningglory tissue recovered 72 hours after application.

Treatment/Rate		Treated[a] leaves	Area above treated leaves	Stem between[b] treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	66.97	1.19	0.31	0.34	0.51	0.31
Acifluorfen	0.6	368.10	0.68	0.95	0.07	0.45	0.07
Acifluorfen	1.2	591.00	1.27	2.83	0.13	2.51	0.09
Control	---	0.02	0.03	0.03	0.01	0.01	0.01

[a] Consisted of the two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves

Appendix Table II-12. Effect of acifluorfen rate on micrograms of ^{14}C-acifluorfen equivalent recovered per gram of ivyleaf morningglory tissue in greenhouse experiments.

Treatment/Rate		Treated[a] leaves	Area above treated leaves	Stem between[b] treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	34.24	0.42	0.61	0.08	0.34	0.02
Acifluorfen	0.3	82.56	0.56	0.75	0.22	0.98	0.05
Acifluorfen	0.6	171.97	1.00	1.73	0.31	4.21	0.19
Acifluorfen	0.9	272.99	1.52	3.61	0.48	3.36	0.16
Acifluorfen	1.2	295.52	2.05	4.05	0.74	6.06	0.27
Control	---	0.02	.01	0.01	0.01	0.01	0.01

[a] Consisted of the two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves

Appendix Table II-13. Effect of acifluorfen rate on micrograms of ^{14}C-acifluorfen equivalent recovered per gram of ivyleaf morningglory tissue in field experiments.

Treatment/Rate		Treated[a] leaves	Area above treated leaves	Stem between[b] treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	16.70	0.25	0.96	0.66	0.34	0.30
Acifluorfen	0.3	34.79	0.19	0.82	0.23	0.31	0.14
Acifluorfen	0.6	86.05	0.43	4.07	0.60	0.83	0.32
Acifluorfen	0.9	135.26	0.43	2.86	0.50	0.89	0.29
Acifluorfen	1.2	174.42	0.83	4.87	1.04	1.44	0.36
Control	---	0.01	0.03	0.09	0.03	0.01	0.03

[a] Consisted of the two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves

Appendix Table II-14. Effect of increasing acifluorfen rates on percent control and fresh weight of pitted morningglory in greenhouse experiments.

Treatment[a]	Rate	Weed Control	Fresh weight
	(kg/ha)	(%)	(g)
Acifluorfen	0.07	20	2.5
"	0.15	85	0.8
"	0.3	90	0.3
"	0.6	98	0
"	0.9	100	0.1
"	1.2	100	0
"	1.8	100	0
"	2.4	100	0
Control	-	0	7.2
$HSD_{.05}$		31.5	2.17

[a] All evaluations were made 20 days after acifluorfen application.

Appendix Table II-15. Effect of increasing acifluorfen rates on percent control and fresh weight of pitted morningglory in field experiments.

Treatment[a]	Rate	Weed Control[b]		Fresh weight
	(kg/ha)	----(%)-----		(g)
Acifluorfen	0.07	50	43	2.4
"	0.15	90	60	3.6
"	0.3	75	60	1.1
"	0.6	98	98	0.3
"	0.9	100	98	0
"	1.2	95	100	0
"	1.8	100	100	0
"	2.4	100	100	0
Control	-	0	0	12.4
$HSD_{.05}$		40	40	7.36

[a] Treatments were applied three weeks after planting on 5-31-82.

[b] Weed control evaluations were made on 6-10-82 and 6-23-82, respectively, with fresh weight measured after the last visual rating.

Appendix Table II-16. Effect of increasing acifluorfen rates on percent control and fresh weight of common cocklebur in greenhouse experiments.

Treatment[a]	Rate	Weed Control	Fresh weight
	(kg/ha)	(%)	(g)
Acifluorfen	0.07	17	12.6
"	0.15	22	11.7
"	0.3	38	11.9
"	0.6	52	11.1
"	0.9	54	10.3
"	1.2	57	9.4
"	1.8	73	9.1
"	2.4	81	7.7
Control	-	0	14.6
$HSD_{.05}$		12	3.09

[a] All evaluations were made 20 days after acifluorfen application.

Appendix Table II-17. Effect of increasing acifluorfen rates on percent control and fresh weight of common cocklebur in field experiments.

Treatment[a]	Rate	Weed Control[b]		Fresh weight
	(kg/ha)	----(%)-----		(g)
Acifluorfen	0.07	48	30	30.5
"	0.15	73	60	13.7
"	0.3	70	45	7.4
"	0.6	93	98	3.4
"	0.9	93	88	1.2
"	1.2	100	98	0
"	1.8	100	98	0
"	2.4	100	93	0
Control	-	0	0	42.9
$HSD_{.05}$		31	31	18.1

[a] Treatments were applied three weeks after planting on 5-31-82.

[b] Weed control evaluations were made on 6-10-82 and 6-23-82, respectively, with fresh weight measured after the last visual rating.

Appendix Table II-18. Micrograms of ^{14}C-acifluorfen equivalent per gram of pitted morningglory tissue recovered 24 hours after application.

Treatment/Rate		Treated leaves[a]	Area above treated leaves	Stem between[b] treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	87.53	0.49	0.73	2.53	0.03	0.07
Acifluorfen	0.6	304.50	1.68	7.46	35.73	0.68	0.36
Acifluorfen	1.2	402.05	2.44	70.99	77.00	44.05	2.83
Control	---	0.03	0.04	0.07	0.04	0.03	0.01

[a] Consisted of two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves

Appendix Table II-19. Micrograms of ^{14}C-acifluorfen equivalent per gram of pitted morningglory tissue recovered 48 hours after application.

Treatment/Rate		Treated[a] leaves	Area above treated leaves	Stem between[b] treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	103.90	0.59	13.79	0.19	0.75	0.06
Acifluorfen	0.6	158.37	3.04	48.73	47.75	1.67	1.05
Acifluorfen	1.2	365.46	1.87	92.28	83.30	0.63	4.16
Control	---	0.04	0.06	0.09	0.01	0.01	0.01

[a] Consisted of two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves

Appendix Table II-20. Micrograms of ^{14}C-acifluorfen equivalent per gram of common cocklebur tissue recovered 24 hours after application.

Treatment/Rate		Treated[a] leaves	Stem between[b] and above treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	27.99	5.69	0.32	0.37	0.09
Acifluorfen	0.6	88.52	74.95	2.57	51.82	0.19
Acifluorfen	1.2	175.32	167.87	3.71	22.69	0.61
Control	---	0.01	0.02	0.01	0.01	0.01

[a] Consisted of two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves + all tissue above treated leaves

Appendix Table II-21. Micrograms of ^{14}C-acifluorfen equivalent per gram of common cocklebur tissue recovered 48 hours after application.

Treatment/Rate		Treated[a] leaves	Stem between[b] and above treated leaves	Stem below treated leaves	Remaining leaves	Root
Acifluorfen	0.15	33.18	7.32	0.42	0.03	0.27
Acifluorfen	0.6	145.74	49.58	0.49	0.12	0.69
Acifluorfen	1.2	149.86	112.79	9.47	83.08	1.16
Control	---	0.02	0.05	0.01	0.01	0.01

[a] Consisted of two treated leaves + petioles

[b] Stem section including the nodes of the treated leaves + all tissue above treated leaves

APPENDIX III

Appendix Table III-1. Analysis of variance of percent control of pitted morningglory in field studies. (ED1).

Source	df	Sum of Squares	F-Value	Probability > F
Year	1	3656	10.25	.0034
Treatment	28	164969	16.52	.0001
Mef. +[a] Bent. vs. Split Appl.	(1)	1653	4.64	.0401
Mef. + Bent. vs. Bent. alone	(1)	153	0.43	.5176
Mef. + Acif. vs. Mef. seq.[b] Acif.	(1)	570	1.60	.2164
Mef..15 + Acif. vs. Mef..3 + Acif.	(1)	111	0.31	.5813
Mef..15 seq. Acif. vs. Mef..3 seq. Acif.	(1)	46	0.13	.7221
Mef. + Acif. vs. Acif. V4	(1)	12	0.03	.8577
Mef. seq. Acif. vs. Acif. V5	(1)	466	1.31	.2627
Mef. seq. Acif. vs. Acif. V4	(1)	259	0.73	.4016
Comb. Mef. & Acif. vs. Acif. V4	(1)	48	0.13	.7161
Comb. Mef. & Acif. vs. Acif. V5	(1)	168	0.47	.4981
Acif. V4 vs. Acif. V5	(1)	23	0.06	.8027
Experimental Error	28	9984		
Sampling Error	174	19267		
Corrected total	231	197876		

[a] + - Tank-mix combinations

[b] seq.- Acifluorfen applied 5 days following mefluidide pretreatment

Appendix Table III-2. Analysis of variance of percent control of pitted morningglory in field studies. (ED2).

Source	df	Sum of Squares	F-Value	Probability >F
Year	1	298	0.75	.3926
Treatment	28	153126	13.83	.0001
Mef. +[a] Bent. vs. Split Appl.	(1)	1568	3.96	.0563
Mef. + Bent. vs. Bent. alone	(1)	666	1.68	.2049
Mef. + Acif. vs. Mef. seq.[b] Acif.	(1)	2440	6.17	.0192
Mef..15 + Acif. vs. Mef..3 + Acif.	(1)	184	0.47	.5007
Mef..15 seq. Acif. vs. Mef..3 seq. Acif.	(1)	192	0.49	.4917
Mef. + Acif. vs. Acif. V4	(1)	295	0.75	.3954
Mef. seq. Acif. vs. Acif. V5	(1)	521	1.32	.2606
Mef. seq. Acif. vs. Acif. V4	(1)	3306	8.36	.0073
Comb. Mef. & Acif. vs. Acif. V4	(1)	1673	4.23	.0492
Comb. Mef. & Acif. vs. Acif. V5	(1)	9	0.02	.8843
Acif. V4 vs. Acif. V5	(1)	901	2.28	.1423
Experiment Error	28	11074		
Sampling Error	174	38250		
Corrected total	231	202748		

[a] + - Tank-mix combinations

[b] seq.- Acifluorfen applied 5 days following mefluidide pretreatment

Appendix Table III-3. Analysis of variance of percent control of pitted morningglory in field studies. (ED3).

Source	df	Sum of Squares	F-Value	Probability > F
Year	1	33600	104.65	.0001
Treatment	28	104682	11.64	.0001
Mef. +[a] Bent. vs. Split Appl.	(1)	780	2.43	.1303
Mef. + Bent. vs. Bent. alone	(1)	95	0.29	.5917
Mef. + Acif. vs. Mef. seq.[b] Acif.	(1)	704	2.19	.1498
Mef..15 + Acif. vs. Mef..3 + Acif.	(1)	52	0.16	.6902
Mef..15 seq. Acif. vs. Mef..3 seq. Acif.	(1)	1633	5.09	.0321
Mef. + Acif. vs. Acif. V4	(1)	851	2.65	.1148
Mef. seq. Acif. vs. Acif. V5	(1)	56	0.18	.6787
Mef. seq. Acif. vs. Acif. V4	(1)	56	0.18	.6787
Comb. Mef. & Acif. vs. Acif. V4	(1)	403	1.26	.2719
Comb. Mef. & Acif. vs. Acif. V5	(1)	13	0.04	.8400
Acif. V4 vs. Acif. V5	(1)	169	0.53	.4745
Experiment Error	28	8990		
Sampling Error	174	34848		
Corrected total	231	182121		

[a] + - Tank-mix combinations

[b] seq.- Acifluorfen applied 5 days following mefluidide pretreatment

Appendix Table III-4. Analysis of variance of percent control of common cocklebur in field studies. (ED1).

Source	df	Sum of Squares	F-Value	Probability >F
Year	1	5840	22.99	.0001
Treatment	28	144642	20.34	.0001
Mef. +[a] Bent. vs. Split Appl.	(1)	78	0.31	.5836
Mef. + Bent. vs. Bent. alone	(1)	153	0.60	.4440
Mef. + Acif. vs. Mef. seq.[b] Acif.	(1)	459	1.81	.1895
Mef..15 + Acif. vs. Mef..3 + Acif.	(1)	0	0	1.0000
Mef..15 seq. Acif. vs. Mef..3 seq. Acif.	(1)	102	0.40	.5313
Mef. + Acif. vs. Acif. V4	(1)	100	0.39	.5354
Mef. seq. Acif. vs. Acif. V5	(1)	3501	13.78	.0009
Mef. seq. Acif. vs. Acif. V4	(1)	756	2.98	.0955
Comb. Mef. & Acif. vs. Acif. V4	(1)	422	1.66	.2080
Comb. Mer. & Acif. vs. Acif. V5	(1)	3050	12.01	.0017
Acif. V4 vs. Acif. V5	(1)	752	2.96	.0963
Experimental Error	28	7112		
Sampling Error	174	20792		
Corrected total	231	178386		

[a] + - Tank-mix combinations

[b] seq.- Acifluorfen applied 5 days following mefluidide pretreatment

Appendix Table III-5. Analysis of variance of percent control of common cocklebur in field studies. (ED2).

Source	df	Sum of Squares	F-Value	Probability > F
Year	1	190	0.67	.4215
Treatment	28	108985	13.63	.0001
Mef. +[a] Bent. vs. Split Appl.	(1)	113	0.39	.5354
Mef. + Bent. vs. Bent. alone	(1)	28	0.10	.7560
Mef. + Acif. vs. Mef. seq.[b] Acif.	(1)	1276	4.47	.0436
Mef..15 + Acif. vs. Mef..3 + Acif.	(1)	33	0.12	.7352
Mef..15 seq. Acif. vs. Mef..3 seq. Acif.	(1)	52	0.18	.6726
Mef. + Acif. vs. Acif. V4	(1)	1111	3.89	.0585
Mef. seq. Acif. vs. Acif. V5	(1)	7084	24.80	.0001
Mef. seq. Acif. vs. Acif. V4	(1)	3906	13.68	.0009
Comb. Mef. & Acif. vs. Acif. V4	(1)	2755	9.65	.0043
Comb. Mef. & Acif. vs. Acif. V5	(1)	5810	20.34	.0001
Acif. V4 vs. Acif. V5	(1)	352	1.23	.2763
Experimemtal Error	28	7997		
Sampling Error	174	32675		
Corrected total	231	149847		

[a] + - Tank-mix combinations

[b] seq.- Acifluorfen applied 5 days following mefluidide pretreatment

Appendix Table III-6. Analysis of variance of soybean yield in field studies.

Source	df	Sum of Squares	F-Value	Probability > F
Year	1	37033638	45.44	.0001
Treatment	28	26598444	1.17	.3440
Mef. +[a] Bent. vs. Split Appl.	(1)	1394450	1.71	.2015
Mef. + Bent. vs. Bent alone	(1)	531480	0.65	.4262
Mef. + Acif. vs. Mef. seq.[b] Acif.	(1)	168488	0.21	.6528
Mef..15 + Acif. vs. Mef..3 + Acif.	(1)	129543	0.16	.6931
Mef..15 seq. Acif. vs. Mef..3 seq. Acif.	(1)	98571	0.12	.7306
Mef. + Acif. vs. Acif. V4	(1)	56913	0.07	.7935
Mef. seq. Acif. vs. Acif. V5	(1)	17996	0.02	.8829
Mef. seq. Acif. vs. Acif. V4	(1)	331838	0.41	.5286
Comb. Mef. & Acif. vs. Acif. V4	(1)	201295	0.25	.6231
Comb. Mef. & Acif. vs. Acif. V5	(1)	1552	0	.9655
Acif. V4 vs. Acif. V5	(1)	150528	0.18	.6706
Esperimental Error	27	22818848		
Sampling Error	170	47481747		
Corrected total	227	135485867		

[a] + - Tank-mix combinations

[b] seq.- Acifluorfen applied 5 days following mefluidide pretreatment

VITA

Scotty Hugh Crowder was born June 26, 1956 in Ackerman, Mississippi to Mr. and Mrs. J. D. Crowder. He was reared on a livestock and row crop farm near Chester, Mississippi. He attended Weir High School, Weir, Mississippi and graduated in 1974.

In June, 1974 he entered Mississippi State University majoring in Weed Science. He graduated with a Bachelor of Science degree in May 1978 and a Master of Science degree in December 1979. After completing the Master of Science degree in Weed Science, he accepted the position of Research Assistant in the Department of Plant Pathology and Crop Physiology at Louisiana State University. In cooperation with the Louisiana State Agricultural Experiment Station and the Louisiana Soybean Promotion Board he pursued a Doctor of Philosophy degree with a major in Weed Science and a minor in Entomology for which he is now a candidate.

EXAMINATION AND THESIS REPORT

Candidate: Scotty Hugh Crowder

Major Field: Plant Pathology (Weed Science)

Title of Thesis: The Potential for Improving Acifluorfen Efficacy by Rate Refinement and Sequential Applications

Approved:

Thomas Harger
Major Professor and Chairman

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Dean of the Graduate School

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